IMPACT OF CLIMATE CHANGE ON THE HEALTHCARE SYSTEM IN BELGIUM

STUDY COMMISSIONED BY THE FEDERAL PUBLIC SERVICE HEALTH, FOOD CHAIN SAFETY AND ENVIRONMENT

Final Report

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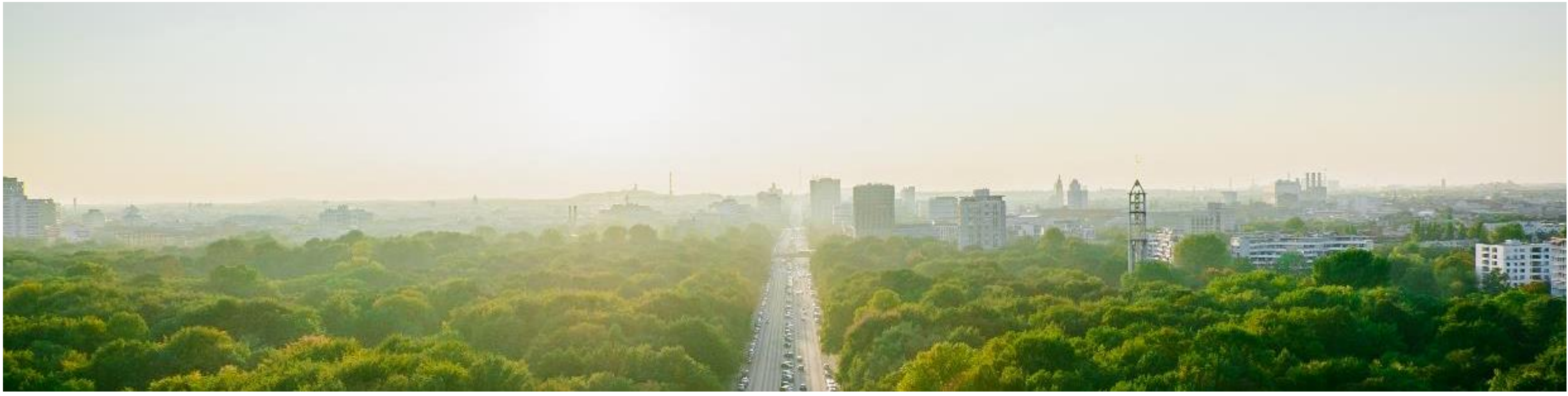
July 2021 (2021/HEALTH/R/2565)



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LIST OF ACRONYMS

ANB	Agentschap Natuur en Bos
AOT	accumulated ozone exposure above a threshold
AVIQ	Agence pour une Vie de Qualité
AZG	Agentschap Zorg en Gezondheid
CMIP	Coupled Model Intercomparison Project
COCOM	Common Community Commission
COVID-19	coronavirus disease 2019
EC	European Commission
ECDC	European Centre for Disease Prevention and Control
EEA	European Environment Agency
EFSA	Euopean Food Safety Authority
ENVIeS	Wallon Environment & Health Plan
EPB	Energy Performance Regulation
EPBD	Energy Performance of Buildings Directive
ETC/CCA	European Topic Centre on Climate Change Impacts, Vulnerability and Adaptation
EU	European Union
FPS Health	Federal Public Service Health, Food Chain Safety and Environment
GP	general practitioner
HNAP	Health National Adaptation Plan
INBO	Flemish Research Institute for Nature and Forest
IPCC	International Panel on Climate Change
IRCELINE	Belgian Interregional Environment Agency
JICEH/CIMES/GICLG	Joint-Interministerial Conference on Environment and Health
KCE	Belgian Healthcare Knowledge Centre
MHD/RHM/MZG	Minimum Hospital Data Set
NAP	Belgian National Adaptation Plan 2017-2020
NCCN	National Crisis Centre
NECP	National Energy Climate Plan
NEHAP	National Environment and Health Action Plan
NIHDI/INAMI/RIZIV	National Institute for Health and Disability Insurance
NMVOC	non-methane volatile organic compounds
NO	nitrogen oxide
NO2	nitrogen dioxide
Nox	nitrogen oxides
NRC	National Reference Centre
O3	ozone
PACE2030	Plan Air Climat Energie à l'horizon 2030 (Wallonia)
PACE-BR	Plan Air Climat Energie Bruxellois
PCSW/CPAS/OCMW/OSHZ	Public Centre for Social Welfare
PM	particulate matter
PWEC	Plan wallon Energie Climat
RAG	Risk Assessment Group
RCP	Representative Concentration Pathways
RMG	Risk Management Group

RMI	Royal Meteorological Institute
SDG	Sustainable Development Goal
SHC/CSS/HGR	Superior Health Council
SPW	Public Service of Wallonia
SRES	Special Report on Emission Scenarios
TBE	tick-borne encephalitis
UHI	urban heat island
UREG	emergency registration
UV	ultraviolet
VAP	Vlaams Adaptatieplan 2021-2030
VEKA	Flemish Energy- and Climate Agency
VITO	Vlaamse Instelling voor Technologisch Onderzoek
VMM	Flemish Environmental Agency
WBGT	Wet Bulb Globe Temperature
WHO	World Health Organization
WNV	West-Nile Virus

1. INTRODUCTION

1.1 CONTEXT

Rising global temperatures have been accompanied by changes in weather and climate. Many places, including Belgium, have seen changes in rainfall, resulting in more floods, droughts, or intense rain, as well as more frequent and severe heat waves. As these changes will likely become more pronounced in the coming decades, they will increasingly present challenges to our society and environment.

Climate change poses risks for all sectors of society and environment: health, labour productivity, infrastructure, energy, agriculture, forestry, ecosystem services, insurance etc. The impacts are projected to worsen in the coming decades, the 2020 report of the Lancet Countdown on health and climate change reported the worst outlook since its establishment in 2015 (Watts et al., 2021). Climate related health effects come in many forms. The direct health impacts from weather extremes such as high temperatures and heat waves, floods, storms, are visible in figures of mortality and injuries or morbidity effects. In Belgium heat waves cause hundreds of extra deaths per year, especially among the elderly and people with chronic conditions. Climate change is altering ecological and environmental conditions, and some areas are becoming more suitable for various infectious diseases. This results in ecosystem-medicated indirect health impacts such as vector-, food- and waterborne diseases, respiratory diseases due to increasing air pollution, exacerbation of allergic reactions due to pollen. Thirdly there are indirect health impacts linked to occupational health and stresses to mental health and well-being.

Mitigation measures are essential to limit global warming and climate change. Adaptation measures are at the same time essential to reduce the impact of the climate change related consequences. A climate resilient health system is a system that is able to anticipate, respond to, recover from, and adapt to climate-related stresses and shocks in order to sustainably improve the health of the population despite an unstable climate (WHO, 2020, 2015). The COVID-19 pandemic has put Belgian (and other) health services under pressure and has made it painfully clear that the risks are greatest for the most vulnerable groups in our society (the elderly, people in poor health or in difficult economic situations). Health systems must therefore be increasingly strengthened so that they remain effective in improving the health of the population in an unstable and changing environment.

To develop relevant and effective adaptation plans and measures, it is of paramount importance to gain insight into the physical climate risk that is expected to affect society.

1.2 OBJECTIVES OF THE STUDY

This report assesses the impact of climate change on the healthcare system in Belgium. For different health sector related treats, the current situation as well as expected changes were identified in a first step. In a second step existing and planned measures were inventoried and evaluated. By combining the information of these two steps, possible gaps were identified leading to the proposal of adaptation measures and recommendations that can ensure the health care system to continue its health-protective and curative role in the context of a changing climate. Across the study, special attention is paid to vulnerable populations.

At the start of the study, an attempt was made to list expected climate change impacts for human health and for the functioning of the Belgian healthcare system. Given that the available resources were finite, a selection was required regarding the climate impacts to be covered. In the end, our choice was guided by discussions with the Steering Committee and by the expertise available within the consortium. The remainder of this report is organized as follows. Section 2 presents the main characteristics of climate change scenarios for Belgium in terms of health-related climatic indicators such as temperature, precipitation, solar radiation and air quality. Section 3 gives an overview of actors in the Belgian healthcare system that are of importance within the study. Section 4 describes climate change adaptation instruments at different levels, going from the global to the local level. Constituting the core of the study, Section 5 presents health effects for the general population with a description of the current situation, expected changes, current and planned measures and the proposal of adaptation actions and measures. The same structure is applied to impacts for the healthcare personnel in Section 6 and infrastructure of the healthcare sector in Section 7. In Section 8 we focus on the energy and IT-infrastructure of the healthcare sector and in Section 9 crisis and risk management are discussed. Section 10 summarises general aspects of the proposed adaptation measures and recommendations. Conclusions are presented in Section 11.

1.3 STUDY APPROACH

In order to gather the perspective on climate risks and adaptation measures within the healthcare sector, a literature-based study was conducted between January 2020 and June 2020. Furthermore the different actors of the health sector were involved in a participatory way through interviews as well as an online survey.

The goal of the **interviews** was to get a better understanding of the main concerns, current or planned measures regarding climate risks for the general population, health care personnel, infrastructure and more. The health care institutions invited for an interview were selected in a way that would reflect the variety of institutions in the health care system. This implies institutions in the 1st, 2nd and 3rd line as well as umbrella organizations and policy-making institutions. An overview of these institutions is included in Table A-11-1 in Appendix A. An interview guide was prepared and interviews lasted about 45 min to 1 hour and were organized through MS Teams. In total, 31 institutions were contacted for an interview by Möbius and VITO, of which 22 were executed (including 30 individuals in total). During several interviews, more than one participant was present. Throughout the text, when conveying information from the interviews, we will refer to this as follows: *Anonymous, Set of interviews on the impact of climate change on the healthcare sector, February-March 2021* (Anonymous, 2021a).

Based on the main trends that rose during the interviews, an **online survey** was developed. The goal of this survey was to gather more information on several preliminary conclusions that could be drawn from the interviews. Specifically, the goal was to focus the online survey on institutions which combine both a residential aspect as well as individuals from vulnerable groups in society. The surveys were created in Alchemer and spread through lists of affiliates from Zorgnet-Icuro and Unessa, with support from the Federal Public Service Health, Food Chain Safety and Environment. Descriptive statistics of the questionnaire are summarized in Table A-11-2. Throughout the text, when conveying information from the online survey, we will refer to this as follows: *Anonymous, Online survey on the impact of climate change on the healthcare sector, April-June 2021* (Anonymous, 2021b).

Readers who prefer to first read a more digestible version of the present full report are referred to the companion *Summary for Policymakers*, which presents the main highlights of this study.

Finally we would like to note that the climate-related events of July 2021, notably the severe floods in Belgium and Germany as well as the extreme heat wave and forest fires in W-Canada/US, show the relevance of the present study. However, considering the duration of this study, these events could not be explicitly taken into account.

2. CLIMATE SCENARIO PROJECTIONS FOR BELGIUM

Climate projections for Belgium have recently been reported on in detail in the SECLIM-study (De Ridder et al., 2020). In the present climate-health study a condensed overview of the main findings regarding expected climate change projections from SECLIM can be used, focusing on issues that are specifically relevant for health.

The climate projections and scenarios described below are largely based on the high-resolution climate simulations for Belgium that were produced in the Belspo-BRAIN project CORDEX.be[1]. This was one of the actions foreseen in the Belgian National Adaptation Plan 2017-2020.The principal results of the CORDEX.be project are described in Termonia et al. (2018). They are based on the Representative Concentration Pathways (RCP) approach used in the 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2014). In addition, we use new and recent (fall 2020) information, among other from the 'Klimaatrapport / Rapport Climatique 2020' (RMI, 2020). This report was published by the Royal Meteorological Institute (RMI) in October 2020, i.e., after the SECLIM study. Finally, we have added a brief section on solar radiation, as its shortwave portion (UV radiation) has known health effects.

2.1 TEMPERATURE

Currently, global temperature has increased by approximately 1.2°C since the pre-industrial era (1850-1900); across Europe, the increase has been 2.2°C[2]. In Belgium, at the station of Uccle, the observed temperature increase has been larger still, approximately 2.5°C (Figure 2-1). (Note that those differences are caused by the different warming rates over land and over oceans, which is itself related to the oceans' high thermal inertia.)

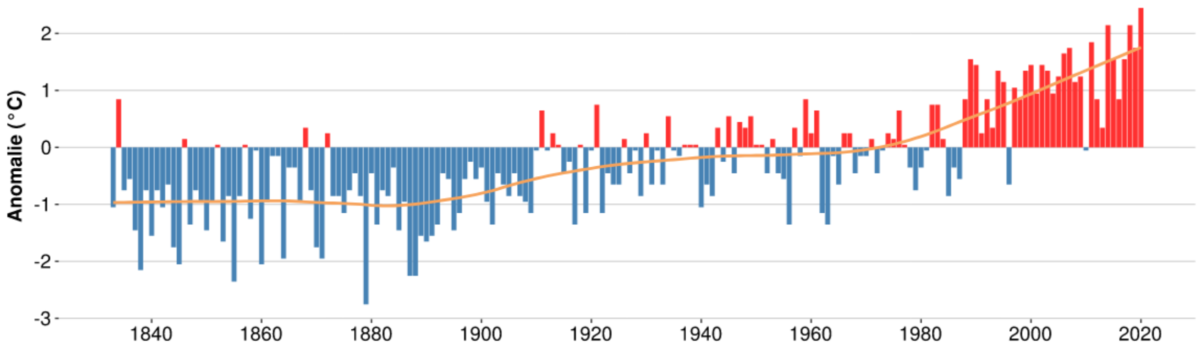

Figure 2-1. Deviation of annual mean temperature in Belgium (Uccle) from the 1961-1990 normals, from RMI[3], also see RMI (2020).

Temperature is expected to further increase in the 21st century, as shown in Figure 2-2, which displays the projected temperature increase at different time horizons compared to the reference period 1976-2005, separately for winter and summer and considering different IPCC climate scenarios (IPCC, 2014; van Vuuren et al., 2011):

- the RCP8.5 scenario, a high-end baseline pessimistic scenario that assumes no policy and a further increase in greenhouse gas emissions towards the end of the 21st century (projected global warming increase 2.6-4.8°C compared to the 1986-2005 average);
- the RCP4.5 scenario, a middle scenario that assumes an emissions peak around 2040, and a decrease afterwards (projected global warming increase 1.1-2.6°C);
- the RCP2.6 scenario, an optimistic scenario that assumes the emissions peak around 2020 and

[1] http://euro-cordex.be/

[2] https://climate.copernicus.eu/climate-indicators/temperature

[3] https://www.meteo.be/nl/klimaat/klimaatverandering-in-belgie/klimaattrends-in-ukkel/luchttemperatuur/gemiddelde/jaarlijks

a decrease afterwards (projected global warming increase 0.3-1.7°C).

(Note the different reference periods used: 1986-2005 in IPCC (2014) and 1976-2005 in Termonia et al. (2018)).

From Figure 2-2 it is apparent that the increase in summer temperature is higher than the increase in winter temperature. When considering temperature extremes (Figure 2-3), it is found that the projected changes are higher still, i.e., hot days will become hotter by a larger increment than average days. Overall, the picture is one of warming summers and milder winters.

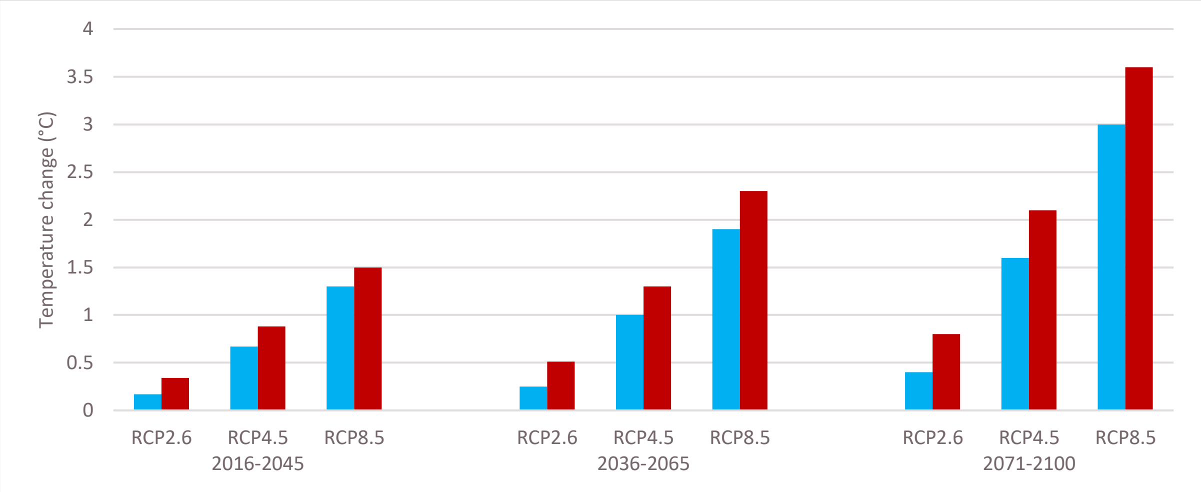

Figure 2-2. Projected temperature change in Belgium, compared to the 1976-2005 period, for different time horizons and climate scenarios, for winter (Dec-Jan-Feb, blue) and summer (Jun-Jul-Aug, red). Values derived from Termonia et al. (2018) as in De Ridder et al. (2020).

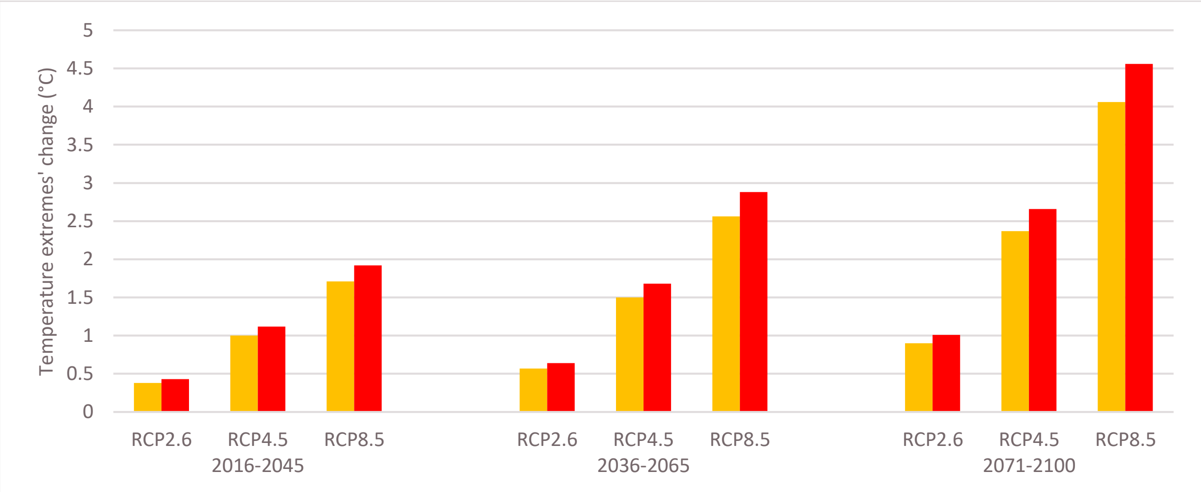

Figure 2-3. Projected change of daily mean temperature extremes in Belgium during the summer (Jun-Jul-Aug), compared to values occurring in the period 1976-2005, for different time horizons and climate scenarios, considering return period of one year (orange) and five years (red). Values derived from Termonia et al. (2018) as in De Ridder et al. (2020).

In a highly urbanized country as Belgium, with a large share of the population living in cities and towns, it is important to account for local urban climate effects, as cities experience the urban heat island phenomenon with higher temperatures occurring in cities compared to nearby rural areas. This urban-rural temperature increment is generally stronger during the day than during the night. Elevated night-time temperatures appear to be an important factor in explaining impacts on human health, as they affect the nightly capacity for people to recover from exposure to daytime heat (Dousset et al., 2011; RMI, 2020).

Figure 2-4 shows the simulated number of heatwave days[1] for Belgium for the present situation and for the middle of the century under a medium climate scenario (approximately RCP4.5). Cities clearly stand out as hot-spots, both under present conditions as in the future. From Table 2-2 it emerges that, in rural areas, the average number of heatwave days increases from 0.9 to 7.1; in urban areas it goes from 5.1 today to 16.8 days in the middle of the century.

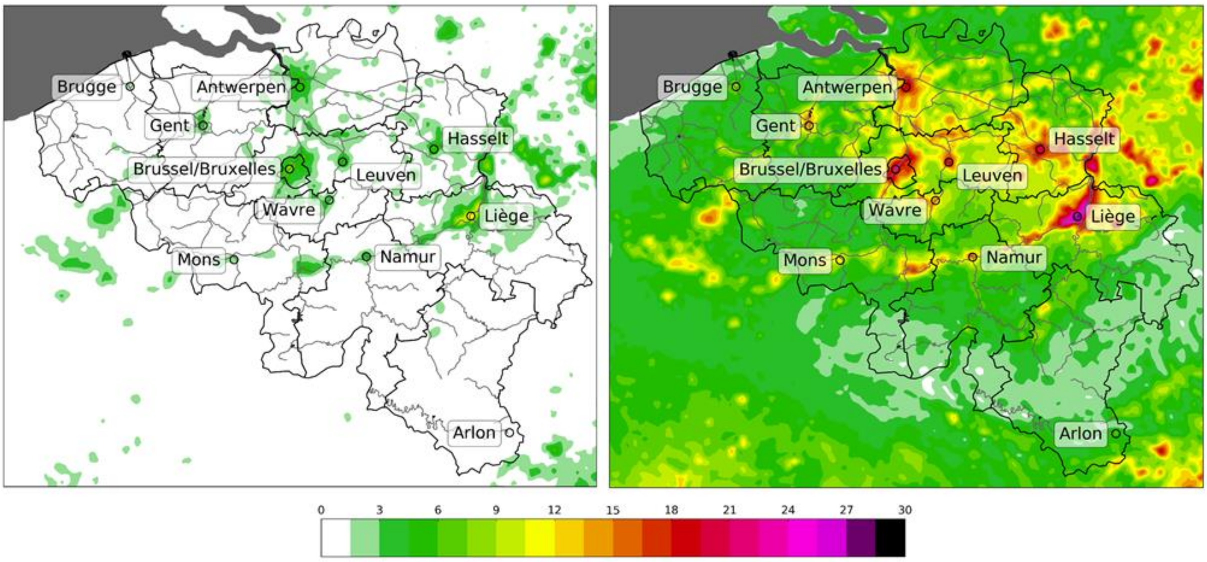

Figure 2-4. Simulated number of annual heatwave days for the periods 1981–2014 (left) and 2041–2074 (right) according to a 'middle' climate scenario (which approximates IPCC scenario RCP4.5). From Wouters et al. (2017).

While Wouters et al. (2017) only considered mid-century conditions, another study (Lauwaet et al., 2018) simulated the number of heatwave days throughout the 21st century, for a domain covering the combined Flemish and Brussels Regions. A synopsis of the main outcome of that study is provided in. It should be noted that the climate scenarios used in that study (and defined in van Lipzig and Willems, 2015) differ from the RCP scenarios mentioned previously. In particular, the 'high' scenario is stronger than the RCP8.5 scenario, and therefore rather unlikely.

The annual number of heatwave days presented in the table is to be compared to the 2000-2016 average value of 3.6 days (domain mean) and 13.0 days (domain maximum for the centre of Brussels). Another reference value stems from the hot summer of 2003, with a domain-mean number of 6.9 heatwave days, rising to 25 heatwave days in the centre of Brussels. It emerges from Table 2-1 that the conditions of the summer of 2003 may become commonplace by mid-century, even under a middle climate scenario. In case of a high scenario, the conditions towards the end of the century are hard to imagine, with – *on average* – nearly 50 heatwave days occurring each year, i.e., a nearly 14-fold increase compared to present-day conditions.

This increase is comparable to results obtained by Hooyberghs et al. (2015) for eight European cities, including Antwerp (for Antwerp in particular also see Mendizabal et al., 2017), which consistently (across the city sample) showed a nearly tenfold increase in the number of heatwave days towards the end of the century, under RCP8.5.

[1] We use the heatwave definition as specified by Brits et al. (2010), and which is used for health purposes, and identifies a heatwave as a period of at least three consecutive days during which the average daily minimum and maximum temperatures exceed 18.2°C and 29.6°C, respectively.

Table 2-1. Projected number of heatwave days occurring on average each year, for different time horizons and climate scenarios, adapted from data presented in Lauwaet et al. (2018). The values in each column correspond to the domain mean, and the values between brackets correspond to the domain maximum. The latter generally corresponds to conditions near the centre of Brussels.

year	climate scenario		
	low (< RCP2.6)	middle (~ RCP4.5)	high (> RCP8.5)
2030	5.2 (14.7)	7.0 (18.0)	10.8 (25.4)
2050	5.9 (15.3)	9.3 (22.0)	18.2 (36.1)
2100	7.2 (17.2)	16.0 (32.8)	49.8 (71.4)

Figure 2-5 shows the present and future projected urban heat island, for Liège. The baseline period and climate scenarios are defined somewhat differently than in Figure 2-4, hence direct comparisons cannot be made. Yet, here it also emerges that climate change is expected to have a vast impact on the number of heatwave days, with a factor 5 to 10 increase towards the end of the century under scenario RCP8.5.

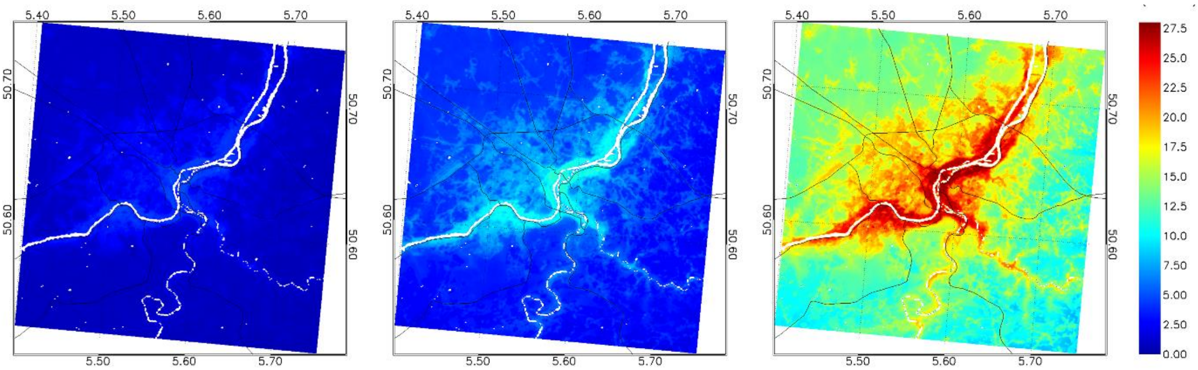

Figure 2-5. Evolution of the annual average number of heatwave days under the RCP8.5 scenario for Liège, for the present (1996-2015, left), near future (2026-2045, middle) and end of the century (2081-2100, right). From Poelmans et al., 2018.

Since climate change is expected to affect not only the number of heatwave days but also their intensity, i.e., the degree to which threshold temperature values are exceeded, it is useful to also consider the annual 'heatwave degree days. This metric (units °C.day) is calculated as the annual sum of daily minimum and maximum temperatures over the thresholds of 18.2°C and 29.6°C occurring on heatwave days (thus excluding, e.g., single isolated days with elevated temperatures). Table 2-2 shows that rural areas exhibit an increase from 2.4 °C.day now to 24.9 °C.day mid-century under scenario RCP4.5. Urban areas, on average, see an increase from 16.8 °C.day to 84.0 °C.day. It is to be recalled that these values are long-term averages over a 34-year period (1981-2014 for present day and 2041-2074 for mid-century conditions), so there will be years with lower and years with higher values.

Table 2-2. Simulated number of heatwave days and heatwave degree days, as average values for rural and urban areas, for present-day conditions and for the time horizon 2041-2070, considering low, medium, and high climate scenarios. The values in the green highlighted column correspond to values shown in Figure 2-4. From Wouters et al. (2017).

		1981–2014	2041–2074		
			low (< RCP2.6)	middle (~ RCP4.5)	high (> RCP8.5)
rural areas	heatwave days [day]	0.9	1.6	7.1	26.9
	HDD [°C day]	2.4	4.6	24.9	145
urban areas	heatwave days [day]	5.1	6.4	16.8	41.5
	HDD [°C day]	16.8	22.4	84	254

A striking observation is in order here. Indeed, recent work based on in-situ climate measurements (De Ridder and Lefebre, 2018, 2019; De Ridder et al., 2020) shows that, in recent years, the annual number of heatwave days exceeds the 1981-2014 average considerably. For instance, in the period 2018-2020 the average annual number of heatwave days for the (semi-)rural station of Steenokkerzeel near Brussels amounts to 5 days; for the centre of Brussels, at the Molenbeek station, the value is 14.7 days (while a tendency towards underestimating heat stress has been noted for this station). Also, when considering the 'heatwave degree days' indicator instead of the number of heatwave days, a city like Antwerp appears to already have attained the level of heatwave degree day values that were only projected for the middle of the century. Concretely, during the past three years (2018-2020) an urban climate measurement site in Antwerp recorded values of respectively 76.7-87.8-97.1 °C.day, i.e., its average (87.2 °C.day) already exceeding the projected value of 84.0 °C.day for the mid-21st century. Observations from a rural station near Antwerp yield a similar picture, exhibiting values of 20.7-23.3-25.1 °C.day over the period 2018-2020, hence an average of 23.0 °C.day, thus getting very close to the projected mid-century value of 24.9 °C.day. Of course, three years of observations is not sufficient to warrant robust conclusions. On the other hand, while the odds that a three-year average produces such high heatwave degree values at the present time have not been assessed, they appear very slim indeed.

Finally, it should be noted that the previous figures pertain to climate scenario RCP4.5, which is a middle-range scenario. In case a high climate scenario was to become true instead, at mid-century we would be facing tens of heatwave days each year *on average*, and a level of heatwave degree days higher by a factor of ten at least compared to today's conditions.

2.1.1 Temperature metrics

Air temperature is the most commonly used metric in popular communication about weather. It is also the basis for the definition of a heatwave. However, air temperature alone does not reflect thermal comfort and associated heat stress as well as the manifestation of health effects. The degree of **heat stress** is determined by air temperature but also by other climatic factors such as the proportion of direct solar radiation, air humidity, and wind. An indicator that takes all determining effects into account is the so-called **Wet Bulb Globe Temperature (WBGT)**, the ISO standard for the quantification of thermal comfort (ISO, 1989). This indicator is used by the Belgian government (FPS-Health and FPS- Employment) to determine when workers are exposed to excessive heat stress[1]. The cooling effects by reducing radiation through shade and evapotranspiration and evaporation of vegetation, is mainly experienced locally, and can be clearly identified in high-resolution WBGT-maps for e.g. cities. In contrast, air temperature maps show only limited spatial variation.

[1] https://werk.belgie.be/nl/themas/welzijn-op-het-werk/omgevingsfactoren-en-fysische-agentia/thermische-omgevingsfactoren/hoe?id=39434#WBGT

Another thermal stress index, which aims to represent the impact of the climatic environment on human physiology, is the Universal Thermal Climate Index (UTCI). Human physiological reaction is simulated by a multi-node model of human thermoregulation, including an adaptive clothing model. For a given combination of wind speed, radiation, humidity and air temperature, the UTCI is defined as the air temperature of the reference environment, which according to the model produces an equivalent dynamic physiological response (Błażejczyk et al., 2013). The calculation of the UTCI is rather arduous; see Bröde et al. (2012) for details. A recent overview of commonly employed heat stress indicators, and their projected trends under climate change, is provided by Schwingshackl et al. (2021).

2.1.2 Urban Heat Island

In a city it is on average warmer than in a rural area, this phenomenon is known as the **urban heat island (UHI) effect**. This phenomenon can be observed all year round but causes problems mainly in the evening and at night during the summer months. In Brussels, for example, during summer the air temperature at night is on average around 3°C higher than in a rural area. This temperature increment increases during a heat wave peaking at 8 to 9°C higher temperatures (Lauwaet et al.,2016). The characteristics of a city not only cause the temperature to rise in the evening and at night, but also cause a higher heat load for people outdoors during the day. The sun heats city streets, buildings and objects considerably during the day (easily up to 40°C and more, even on not-so-hot days). Due to the high surface temperatures of these materials, the heat radiation they emit will increase significantly and create an additional radiation load that is clearly felt in a city. This effect manifests itself mainly in the evening and at night, when the city tries to transfer its stored heat to the atmosphere. However, due to the low sky view factor, a limited percentage of the absorbed heat can be released. The remaining heat is trapped in the urban fabric, creating warm nights characterised by heat stress (Lauwaet et al.,2016). Heat stress is hence greatest in cities for several reasons: (1) by the frequent occurrence of buildings and pavements that have a high heat-absorbing capacity, (2) by a compact structure that dissipates the absorbed heat very slowly, (3) by the lack of cooling elements such as greenery and water and (4) by the high population density and the presence of vulnerable target groups (the elderly, young children) (Lauwaet et al.,2016).

2.2 PRECIPITATION

Projected changes in precipitation exhibit a very strong seasonal component (Figure 2-6). Indeed, while on average precipitation is expected to increase only slightly, projections show a relatively large increase in winter accompanied by a large (though lesser in magnitude) decrease in summer precipitation.

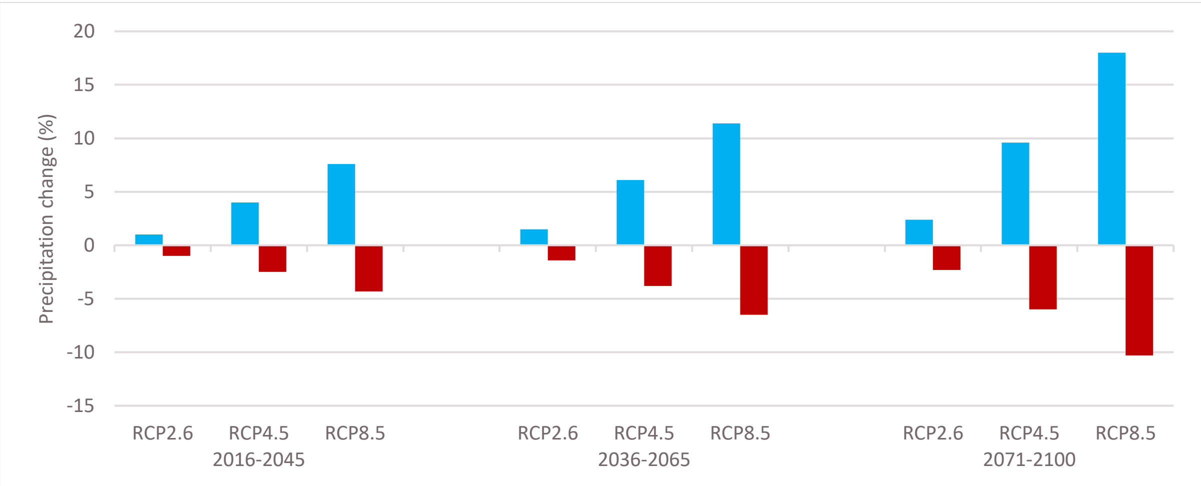

Figure 2-6. Projected precipitation changes in Belgium, compared to the 1976-2005 period, for different time horizons and climate scenarios, for winter (Dec-Jan-Feb, blue) and summer (Jun-Jul-Aug, red). Values derived from

Termonia et al. (2018) as in De Ridder et al. (2020).

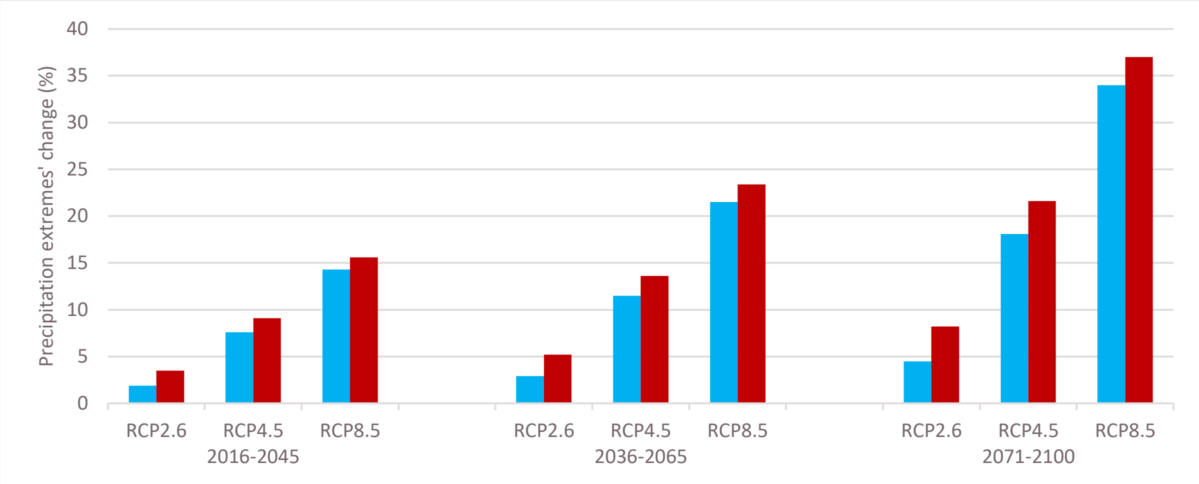

Figure 2-7. Change in extreme (5-year return period) daily precipitation, for winter (Dec-Jan-Feb, blue) and summer (Jun-Jul-Aug, red) in Belgium, for the periods 2016–2045, 2036–2065 and 2071–2100, compared to the reference period 1976–2005. Values derived from Termonia et al. (2018) as in De Ridder et al. (2020).

In recent decades Belgium has experienced an increase in the number of days with extreme precipitation (i.e. days with at least 20 mm precipitation), and the projected trends are upward (RMI, 2020). However, whereas the overall seasonal-average precipitation amounts (Figure 2-6) show very different trends between winter and summer, precipitation *extremes* exhibit a rather similar trend between both seasons (Figure 2-7).

With respect to hail, climate projections conducted within CORDEX.be (Termonia et al., 2018) for the end of the century under IPCC scenario RCP8.5 point towards a reduced number of hail events but an increase of the main hailstone size.

Finally, little (or at best very scattered) evidence appears available regarding the impact of cities on local precipitation patterns. Yet, cities do adversely affect local pluvial flooding because of the high share of impermeable surfaces that convert a very large share of incoming precipitation into overland flow, which may induce flooding.

2.3 DROUGHT

High temperatures and solar radiation levels (inducing a high level of evapotranspiration) combined with reduced spring and summer precipitation amounts lead to depletion of soil moisture and overall dry conditions. Drought may affect the release of pollen, the atmospheric load of dust and certain types of aerosol, and the dryness of the air, all of which may have impacts on human health, particularly in connection to respiratory disease.

In recent years, Belgium has been struck by prolonged drought conditions (RMI, 2020), the drought occurring in 2018 being categorized as exceptional. Regarding projected future drought, Spinoni (2018) assessed drought in Europe using indicators that combine changed precipitation and evapotranspiration to provide a complete picture of drought beyond the sole ‘meteorological drought’ indicator, which accounts for precipitation alone. From figures presented in Spinoni (2018) it emerges that Belgium will likely experience a significantly enhanced (mainly summer) drought frequency and severity, already in the middle of the century (2041-2070) under RCP4.5, and very outspokenly so towards the end of the century under RCP8.5.

2.4 SOLAR RADIATION

Solar radiation enhances human thermal stress, in particular for outdoor workers in e.g. the agriculture or construction sectors. Moreover, the share of solar radiation occurring in the shorter wavelengths in the form of UV radiation has a direct harmful effect on human health in case of overexposure. Over the past century, the annual number of sunshine hours has fluctuated over rather long time scales (Figure 2-8), with a clear upward trend since the early 1980's. This solar brightening has been attributed to a decreasing cloud cover (Wyard et al., 2018) and reduced air pollution, in particular in the form of atmospheric aerosol (RMI, 2020).

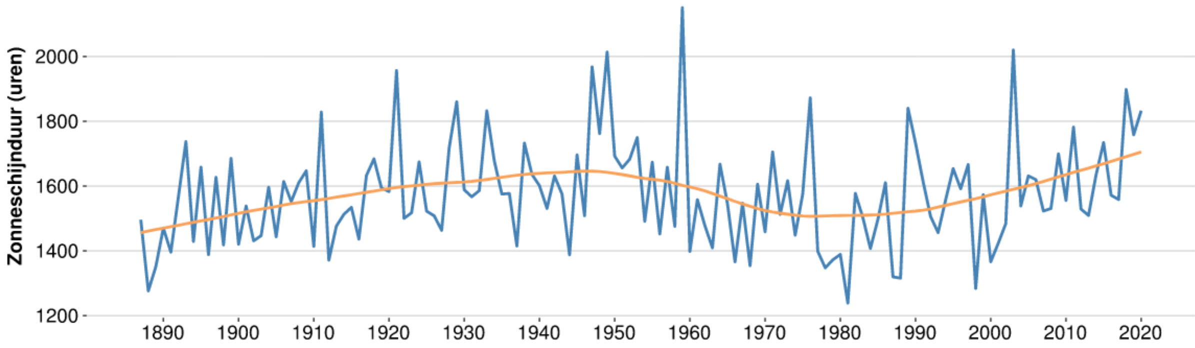

Figure 2-8. Evolution of the annual number of sunshine hours at the station of Uccle. From RMI[1], also see RMI (2020).

Projections of the future surface downwelling solar radiation fluxes come with a large uncertainty (Bartók, 2018). Moreover, Belgium being positioned at the divide between areas where effects are opposite (solar radiation increase towards the South, decrease towards the North) adds to this uncertainty.

There is evidence (Bartók, 2018), though, that in summer Belgium will experience an increased flux of solar radiation by a few W m^{-2} (period 2031-2060 under scenario RCP4.5, compared to 1971-2000). The extent to which this would affect harmful downwelling UV radiation is less clear, as this would also be affected by other aspects such as future stratospheric ozone concentrations, which acts as a protective filter for UV radiation.

2.5 STORMS

Observations do not show a clear trend in the occurrence of extreme wind speed values in Belgium, although in recent decades storm days have declined slightly (RMI, 2020). Also, projections for the daily average wind speed in Europe do not show a clear trend towards the future (see, e.g. Dantec and Roux, 2019). This appears to be also the case for Belgium, although it is expected that the wind speed during the most intense storms may increase by up to 30% (Brouwers et al., 2015). Summertime thunderstorms are also sometimes accompanied by very high wind speed values locally, such as e.g. during the Pukkelpop festival disaster in August 2011 which caused several casualties.

2.6 SEA LEVEL RISE

Sea level rise poses a potential threat to human health by its impact on flooding in coastal areas or along tidal rivers such as the Scheldt river in Antwerp.

[1] https://www.meteo.be/nl/klimaat/klimaatverandering-in-belgie/klimaattrends-in-ukkel/zonnestraling/zonneschijnduur

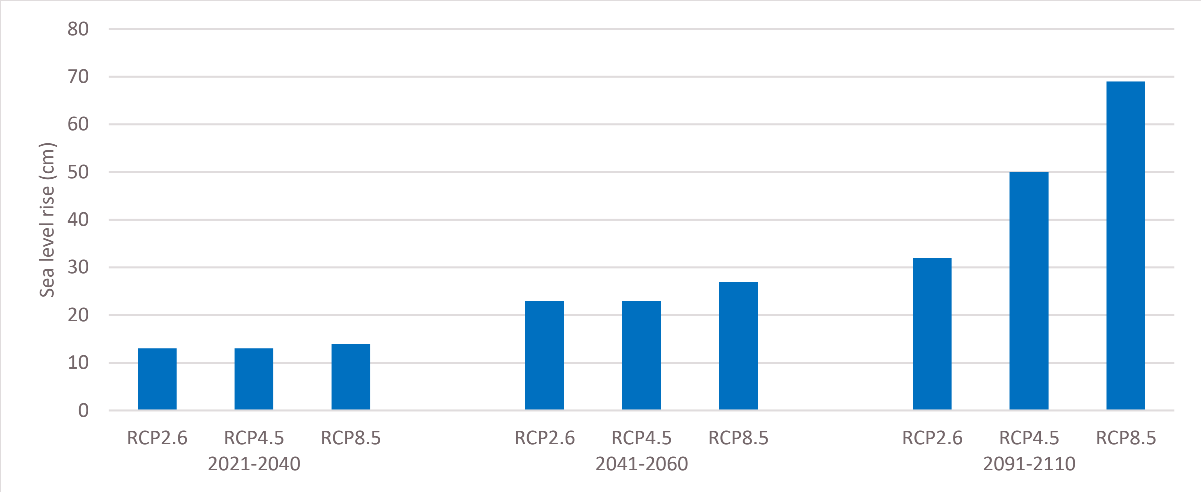

Figure 2-9. Sea level rise at Ostend with respect to 1991–2010 for different time horizons and climate projections, according to Kopp et al. (2014).

Projections of sea level rise at Ostend are shown in Figure 2-9, with values of approximately 25 cm at mid-century, steeply rising towards the end of the century in all scenarios. From these trends in sea level rise, it is expected that the surface area, the water depth and number of dangerously floodable vulnerable facilities for a millennial storm surge will increase under climate change towards the end of the century[1].

2.7 AIR QUALITY

Projections of air quality tendencies under a changing climate are difficult to establish given the high uncertainty regarding levels of pollutant (precursor) emissions, especially from traffic, but also from residential and other sources, because of unanticipated technological developments and unknown degree of market acceptance of new technologies (electric car, district heating, among others).

Still, a few studies have been conducted for Belgium. Deutsch et al. (2010), using the year 2003 as a proxy for future climate change conditions, found that because of the hot summer, 2003 exhibited a considerably larger number of days with PM_{10} (particulate matter, particles with diameter smaller than 10 µm) and $PM_{2.5}$ (particulate matter, particles with diameter smaller than 2.5 µm) concentration values in exceedance of standard health limit values compared to the 'average' year 2007. With respect to ozone, it was found that the AOT60[2] featured values around five times higher in 2003 than those of the year 2007. The main conclusion in Deutsch et al. (2010) was that climate change has the potential to partially or completely undo the beneficial effects of anticipated pollutant emission reductions, among others because of the higher temperatures (enhanced atmospheric chemical reactions) and the occurrence of drought spells (reduced washout from precipitation).

In another study, Lauwaet et al. (2014) simulated ozone concentrations under current (2000-2009) and future (2025-2036, RCP4.5) climatic conditions. They found that towards 2030 we can expect up to 30 % higher average ozone concentrations, though most of this is related to the (assumed) changed emission reductions, in particular of NO_x (nitrogen oxides), leading (somewhat paradoxically at first sight) to a lesser ozone destruction hence higher ozone concentration. Yet, keeping the (ozone precursor) emissions constant (in order to isolate the climate impact), showed increased future (2030) average ozone concentrations by about 10%. When considering ozone peaks, taken 95th percentile values, a decrease has been observed in the concentration levels as the reduced NMVOC (non-methane volatile organic compounds) and NO_x emissions limit the O_3 formation during these episodes. This shows that the emission reductions enforced e.g. by EU policy and taken up in RCP4.5 pay off

[1] See https://klimaat.vmm.be/nl/kaartapplicatie-thema-5

[2] the AOT60 is the accumulated ozone exposure above a threshold of 60 ppb (= 120 µg/m³) and strongly relates to the health effects of ozone on the population

during peak episodes in summer so that the number of days exceeding the 8 h maximum threshold of 120 µg m^{-3} was reduced by 25% over Belgium.

In the 2020 report of the Flemish Environmental Agency (VMM) an analysis has been performed of the ozone concentrations (in Flanders) since 1990 (VMM, 2020a). It has been observed that the background ozone concentrations increase while the ozone peaks decrease, in accordance with the aforementioned model calculations by Lauwaet et al., (2014). Indeed, for Belgium the number of days with ozone concentrations higher than 240 µg m^{-3} is decreasing in time. If we consider the period 2010-2020: three days in 2010, two days in 2013, one day in the years 2012, 2015, 2019 and 2020, no ozone alert days in 2011, 2014, 2016, 2017 and 2018[1]. The increase in background concentrations has been observed in the entire northern hemisphere and can be attributed to increasing emissions e.g. in China, while in Western-Europe there was a decrease in the emissions of the main ozone precursors. The decrease in the peak concentrations can be attributed by EU policy, primarily the reduction of the emissions of NMVOC by traffic measures, as in our region ozone-formation is VOC-limited. The associated decrease in NO_x-emissions does enhance the background concentrations of ozone (because of reduced titration potential with NO).

[1]https://www.irceline.be/nl/luchtkwaliteit/metingen/ozon/historiek/O3_240_since1979.png/image_view_fullscreen

3. HEALTHCARE SYSTEM IN BELGIUM

3.1 GENERAL

Health systems include all facets of healthcare (e.g., acute care, chronic care, long-term care, and mental healthcare), as well as all aspects of care delivery (e.g., healthcare personnel, care facilities, supply chains, and pharmaceuticals), health governance and leadership, and health information and technology, including surveillance and financing (WHO, 2015).

Below we give an overview of the different actors in the Belgian healthcare system with policy making institutions, governance structures, organizations, etc. We do not intend to give a complete overview but rather to focus on the actors that are of importance within this study.

3.2 POLICY MAKING INSTITUTIONS

Belgium is a federal state with three communities and three regions. In Belgium health policy and the regulation of the health care system is divided among the federal government, the (language-based) communities, provinces and local authorities. To facilitate cooperation and to coordinate policies between the different levels, inter-ministerial conferences (IMC) public health are regularly organized.

The Federal authorities are competent for matters in the general interest of all Belgians, such as the national compulsory health insurance, the setting of the hospital budget and of general organization rules, the regulation of health products and activities, the regulation of health care professionals, and patients' rights.

The Ministry of Health and the Federal Public Service Health, Food Chain Safety and Environment – Health Directorate (FPS Health)[1] are responsible for the general organization and planning rules of the health system, this includes services concerning healthcare, environment, animal, plant and nutrition and management of medical expertise. MEDEX performs medical assessments for public sector personnel, the general public (drivers, pilots and captains) and war victims as well as military victims. They issue medical certificates for incapacity for work (absence due to illness, work-related accident or occupational disease), early retirement for medical reasons. Saniport is the sanitary police for international traffic, they perform health-related inspections of ships and aircrafts. The Superior Health Council (SHC/CSS/HGR)[2] draws up scientific advisory reports to guarantee and enhance public health, the reports aim at providing guidance to political decision-makers and health professionals. The federal research centre Sciensano is linked to FHS for policy-supporting research and consultancy. The National Institute for Health and Disability Insurance (NIHDI/INAMI/RIZIV)[3] manages the compulsory health insurance. The Belgian Healthcare Knowledge Centre (KCE)[4] is a research centre related to healthcare.

The communities are the main competent authorities in the fields of care for elderly, disabled care (including the granting of allowances), mental health care, primary and home care and rehabilitation. They are also the main competent authorities for health promotion and disease prevention (a.o. registration infectious diseases). The competent public authorities are Agentschap Zorg en Gezondheid (AZG)[5] for the Flemish Community in the Flemish Region), Agence pour une Vie de Qualité (AVIQ)[6] for the Walloon Region, and Ministerium der Deutschsprachigen Gemeinschaft for the German-speaking community. In Brussels Capital Region the Common Community Commission (COCOM) is the competent authority for community matters not exclusively relating to one of the two communities.

[1] https://www.health.belgium.be/nl
[2] https://www.health.belgium.be/en/superior-health-council
[3] https://www.inami.fgov.be/fr/Pages/default.aspx
[4] https://kce.fgov.be/en
[5] https://www.zorg-en-gezondheid.be/
[6] https://www.aviq.be/

The Brussels-Capital Health and Social Observatory[1] and Iriscare[2] are responsible for health-related matters.

At the provincial level, the provincial authority is responsible for disaster planning and management of emergency services

Every municipality in Belgium has a Public Centre for Social Welfare (CPAS/OCMW/OSHZ). They provide social services such as financial help, medical help, housing and legal advice.

3.2.1 Environment and health

The National Environment and Health Action Plan (NEHAP)[3] is a framework for planning and implementing environmental health actions at all institutional levels in Belgium. NEHAP promotes a multi-level and multi-sectoral approach in order to implement policies related to health and environment. NEHAP is being monitored by the Joint-Interministerial Conference on Environment and Health (JICEH/CIMES/GICLG), consisting of all ministers (federal, community, regional) with competence in health and environment, together with the Cell Environment-Health (collaboration between all Belgian administrations responsible for environment and health).

3.3 FIRST LINE HEALTHCARE

Primary care can be used by anyone without a referral. This includes care provided by general practitioners (GPs) (and practice auxiliaries), care provided by dentists (and other oral healthcare providers such as dental hygienists, orthodontists and dental prosthetists), physiotherapy, pharmacy care, home nursing, social work, psychological care at a consultation centre.

Belgium has primary care centres ('maisons medicales'[4] in French, 'wijkgezondheidscentra'[5] in Dutch) where different healthcare providers and professionals operate, including GPs, nurses, and physiotherapists. There are big differences in the coverage by primary care centres: it is estimated that in Brussels 14% of the beneficiaries of the obligatory health insurance are patient in a primary care centre, while this is only 2% and 4.4 % for Flanders and Wallonia, respectively[6].

Different initiatives exist to optimize the collaboration between local actors of primary care.

A general practitioners association/zone groups all general practitioners (GP) working in a certain geographic area comprising one or more municipalities.

In Flanders and Brussels there is a geographical division of 60 primary care zones ('eerstelijnszone' in Dutch)[7], each zone covering an area of 75,000 to 125,000 inhabitants spread over one or more municipalities. The first-line zones were set up to facilitate and support cooperation between local authorities, care providers and the person in need of care and support. Since 2020 each first-line zone is managed by a care council ('zorgraad' in Dutch), which is a non-profit organization with representatives from care, well-being, local authorities and optional partners. The care council brings together knowledge and expertise from various disciplines together with the person with a care and support need. They are supported by VIVEL[8] with training courses and activities based on their needs and requirements. The care council works on 4 levels:

- At the individual level of people with a care need;
- At the neighbourhood level providing informal and neighbourhood-oriented care;
- At the level of the first line zone;
- At the community level.

[1] https://www.ccc-ggc.brussels/en
[2] https://www.iriscare.brussels/fr/
[3] https://www.nehap.be/en
[4] https://www.maisonmedicale.org/
[5] https://vwgc.be/
[6] https://atlas.ima-aim.be/databanken
[7] https://www.eerstelijnszone.be/home
[8] https://www.vivel.be/

For Wallonia a similar initiative of creating geographical divisions of primary care actors is under consideration. Currently there are local groupings but there is no structure at the level of the French community.

The implementation of prevention policies and operational plans at a local level is coordinated by local health promotion centres (‘Lokaal Gezondheidsoverleg’ (LOGO)[1] in Flanders and Brussels, ‘Centre Local de Promotion de la Santé (CLPS)[2] in French community). They ensure the interface between the local level and the different government levels and also respond to the health-related demands of all actors in their working area. There exist 15 Logo’s and 9 CLPS, in every centre works a medical environment expert specialized in environment and health. They support local actors in the development of projects and actions, initiate and/or strengthen networks of local actors, support and raise awareness of local authorities on the integration of health promotion in their policies or plans etc.

The networks ‘Academie voor de Eerste Lijn’[3] and Be-Hive[4] focus on research and education within the first line. These are more academic collaborations, including universities, to strengthen and support the first line healthcare.

3.4 SECOND AND THIRD LINE HEALTHCARE

The second and third lines cover healthcare providers in hospitals.

Since 2015 all hospitals (except psychiatric hospitals and revalidation hospitals) are required to join a network within a geographical area, forming Local-regional hospital networks (De Regge et al., 2019).

Every hospital (network) has a Hospital Emergency Plan (HEP/ZNP/PUH), this is an action plan with procedures to follow in case of major accidents inside and outside the hospital. The aim of the hospital emergency plan is to undertake the necessary actions with all disciplines within the hospital to increase surge capacity and to transform the hospital organization as quickly as possible from day-to-day assistance to urgent joint emergency assistance, without jeopardising the care for the patients already admitted. This involves a quick increase in the capacity of the hospital in terms of number of beds, equipment and staff. The FPS Health foresees a template, guidance, check list, action maps and an e-learning module in order to develop a HEP[5]. They also provide a tool to perform a risk analysis of the hospital. The concrete elaboration for a hospital (network) is done by the hospital (network) in consultation with local emergency and intervention plans.

3.5 CRISIS MANAGEMENT STRUCTURES

Under the framework of the WHO International Health Regulations (2005) and the European Commission (EC) decision on Serious Cross Border Threat to Health, Belgium designed in 2007 an organizational model to detect, assess, notify and control potential public health hazard. The Belgian system is based on a triad of actors:

- The National Focal Point (NFP) is responsible for international notification;
- A Risk Assessment Group (RAG), composed by permanent representatives from the health authorities and coordinated by Sciensano, conducts daily surveillance of potential health threats and, when needed, prepares risk assessments and proposes actions to be implemented;
- A Risk Management Group (RMG), composed of representatives from the ministries of health and coordinated by FPS-Health, decides on the notification and on the control measures

[1] https://www.vlaamse-logos.be/

[2] http://sante.wallonie.be/sites/default/files/ANNEXE%204%20R%C3%A9f%C3%A9rentiel%20des%20CLPS%20-%20juin%202014.pdf

[3] https://academievoordeeerstelijn.be/

[4] http://be-hive.be/

[5] https://www.health.belgium.be/en/node/30432

proposed by the RAG.

In case control measures are adopted by the RMG, these measures are implemented in consultation with the regions. The RAG ensures the post-assessment phase by monitoring the event for its acute health impact and by evaluating the intervention and identifying lessons learned. The RMG and RAG are under the supervision of the IMC public health.

Crisis management and emergency planning is organized at different levels in Belgium. At the federal level the CNNC (Nationaal Crisiscentrum) coordinates, in the event of a crisis, the interdepartmental and interdisciplinary action of the government with all the services and sectoral authorities concerned. They provide logistic support and crisis communication. The civil protection can reinforce local services. At the provincial and municipality level crisis management structures are in place.

3.6 HEALTH DATA

3.6.1 Mortality data

Surveillance of all-cause mortality is carried out on a weekly basis by the Epidemiology of infectious diseases Service of Sciensano[1]. The mortality monitoring model (Be-MOMO) is designed to serve as a tool for rapid detection and quantification of unusual mortality which might result from disease epidemics such as influenza or from extreme environmental conditions such as heat waves. Data are updated on a weekly basis. Mortality and population data are provided by the National Register and Statbel, respectively. The mortality file contains information on all deaths that were registered by the Belgian municipalities during the week before (ending on Saturday at mid-day). The data comprise the date of birth, date of death, gender, nationality, place of residence and place of death. The causes of death are unknown. Because of a considerable variation in the rapidness of death registration (ranging from a few days to many weeks after the actual date of death), figures for recent periods are incomplete. Around 95% of mortality data are available after 2 weeks.

3.6.2 Hospitalization data: MHD/RHM/MZG

The Minimum Hospital Data Set (MHD/RHM/MZG) is an anonymized registration system for administrative, medical and nursing data. All non-psychiatric hospitals in Belgium are required to contribute to it. Since 2008, the MHD integrates the Minimal Clinical Data (MCD/RHM/MZG), the Minimal Nursing Data (MND/RIM/MVG), and the Mobile Urgency Group Data (MUG/SMUR). The data are sent by the hospitals via Portahealth to the federal authorities every six months (i.e. twice a year) and contain information about the stays of patients discharged from the hospital during that six-month period.

3.6.3 Emergency department data

Data on emergency department visits are registered in the MHD via the Mobile Emergency Group Registration (MUGREG) and the emergency registration (UREG). The MUGREG was started in 2003 and is intended to enable the government to evaluate the functioning of the MUG. The UREG has been launched since 2016 and will mainly serve as a real-time warning system to quickly detect health crises. Currently the data are being registered but not exploited.

3.6.4 General practitioners' data

Intego data are collected in general practices in Flanders. Intego has a database that contains about 3 million diagnoses, 27 million laboratory results and 12 million prescriptions for medication. Since 2017 the registration network includes approximately 100 general practitioners' practices with about 400 GPs, spread across Flanders. Currently there are data from more than 250.000 different patients

[1] Be-MOMO, Belgian Mortality Monitoring: Sciensano: https://epistat.wiv-isp.be/momo/

included in the database.

The Network of General Practitioners comprises about 120 general practices all over Belgium who weekly report data about different specific health problems (infectious and non-infectious diseases). The registration and analysis of the data is carried out by Sciensano[1].

3.6.5 Medication use

Farmanet/Pharmanet[2] contains information on reimbursed medicines and medical devices delivered in public pharmacies. These are medicines delivered to members of the seven mutualities of Belgium within the framework of the compulsory health insurance. The database contains the administrative and accounting data of each medication registered by the mutuality.

The IMA database includes information on the reimbursed care and medicines. The data is collected by the 7 health insurance funds and processed, analyzed and made available for research by the IMA.

3.6.6 Laboratory data

Sciensano coordinates the network of sentinel laboratories (Epilabo) and the National Reference Centres (NRC) for surveillance of epidemiological trends and the warning of outbreaks[3]. The sentinel laboratories are distributed evenly in Belgium and they notify and transfer voluntarily data for certain pathogens. For different pathogens weekly data are available on Epistat dashboard for Belgian Infectious Diseases[4]. Sciensano performs regularly epidemiological surveillance for different pathogens, reports are available online[5].

3.6.7 Belgian Health Interview Survey

Every five years 10,000 individuals are surveyed through the Belgian Health Interview Survey[6]. This allows to study the evolution of the population's health status and the changes at the level of the risk factors.

4. CLIMATE CHANGE ADAPTATION IN HEALTHCARE SECTOR

[1] https://www.sciensano.be/en/network-general-practitioners
[2] https://www.inami.fgov.be/fr/statistiques/medicament/Pages/statistiques-medicaments-pharmacies-pharmanet.aspx
[3] https://nrchm.wiv-isp.be/nl/default.aspx
[4] https://epistat.wiv-isp.be/dashboard/
[5] https://epidemio.wiv-isp.be/ID/Pages/Publications.aspx
[6] https://www.sciensano.be/en/about-sciensano/sciensanos-organogram/lifestyle-and-chronic-diseases/health-surveys

4.1 CLIMATE ADAPTATION

4.1.1 Risk asssessment

The IPCC defines risk as a combination of three components: hazard, vulnerability and exposure. However, human responses to climate change can also affect these different components. Mitigation and adaptation responses carry the potential for positive and adverse consequences and, thereby, affect the overall nature and complexity of risk. Simpson et al. (2021) set up a new risk framework integrating response into the centre of climate risk assessment and management, particularly when they hold the potential for negative or positive outcomes for human or ecological systems, see left panel of Figure 4-1. Climate risk assessment also needs to consider interactions between multiple risks, as illustrated in the right panel of Figure 4-1, risks can aggregate, compound and cascade with others. Aggregation occurs when risks with unrelated casues occur simultaneously. Compound climate risks are those where two or more climate risk drivers affect each other to increase the overall severity of risk. A cascade is when one risk triggers multiple other risks in a proliferation of interactions.

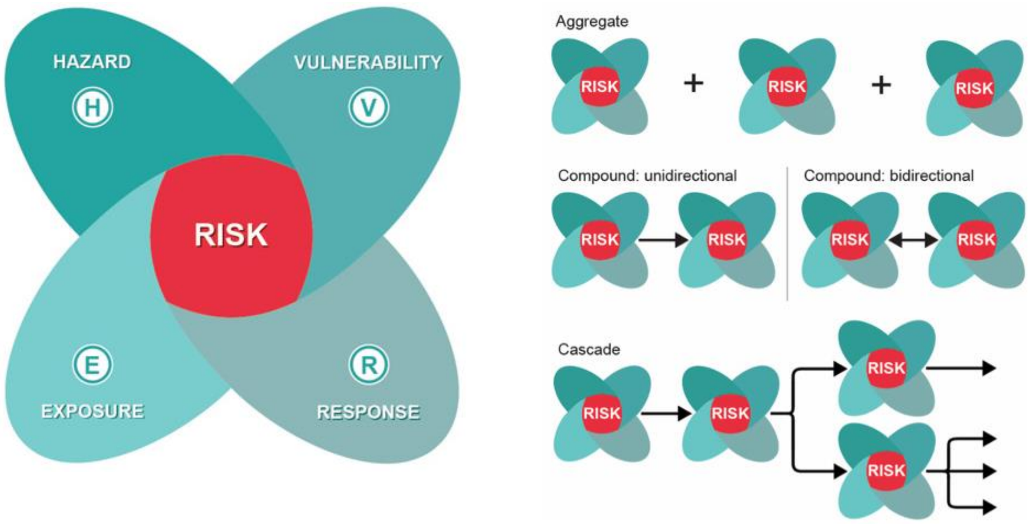

Figure 4-1. Climate change risks. Left: Determinants of a risk: hazard, vulnerability, exposure and response to a climate change. Right: Interacting risks: compounding and cascading interactions generate increasing complexity for risk assessment. Source: Simpson et al. (2021).

4.1.2 Climate change adaptation policy support tool

Figure 4-2 shows the adaptation support tool aiming to assist policy makers and coordinators on the national level in developing, implementing, monitoring and evaluating climate change adaptation strategies and plans. The tool was developed by the European Climate Adaptation Platform Climate-ADAPT. This is a partnership between the European Commission and the European Environment Agency (EEA). Climate-ADAPT is maintained by the EEA with the support of the European Topic Centre on Climate Change Impacts, Vulnerability and Adaptation (ETC/CCA).

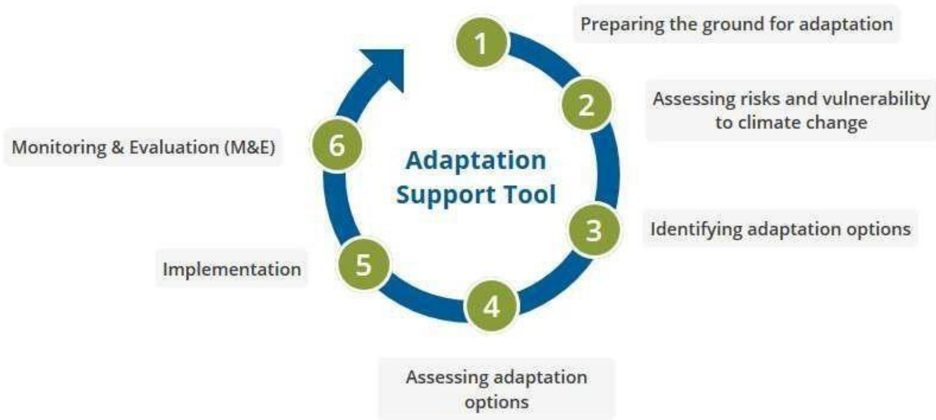

Figure 4-2. Adaptation support tool. Source: Climate-ADAPT.

4.2 CLIMATE CHANGE ADAPTATION IN HEALTH SYSTEMS

4.2.1 Global level

The Sendai Framework adopted by the UN in 2013 is the road map to make communities safer and more resilient to disasters (UNDRR, 2015). It proposes four priority areas for action that are highly relevant to reducing risks to health care facilities:

- Understanding disaster risk: call for periodic assessments, baselines determination, information management, and development of disaster risk services which includes making data and scientific information usable to decision-makers;
- Strengthening disaster risk governance to manage disaster risk: Clear roles and responsibilities, and enhanced coordination in disaster risk management to ensure a multi-hazard and multisector understanding of disaster risk, can benefit health care facilities at the local level. Health care facilities would benefit from participating in preparations of local disaster risk reduction strategies and plans;
- Investing in disaster reduction for resilience. The framework emphasizes the need to build critical infrastructure “better from the start” and refers to ensuring the resilience of work places and of health systems;
- Enhancing disaster preparedness for effective response, and to “Build Back Better”. The Sendai framework calls for the preservation of the functioning of critical infrastructures, and the continued provision of services, very relevant to health care facilities. The call to “Build Back Better” refers to disaster risk reduction measures in recovery, rehabilitation and reconstruction measures.

In September 2015, the United Nations General Assembly formally adopted the Sustainable Development Goals or SDGs with the adoption of Agenda 2030 for Sustainable Development. SDG 13 focuses on "Climate Action: Take urgent action to combat climate change and its impacts". This also contains a clear reference to climate adaptation, which translates into Target 13.1: "Strengthen the resilience and adaptive capacity of climate-related hazards and natural disasters in all countries" and Target 13.3: "Enhance education, awareness and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning". SDG 9 “Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation” calls for the development of quality, reliable, sustainable and resilient infrastructure, and also upgrading infrastructure and retrofitting industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and processes.

In 2015, the Paris Agreement was concluded at the 21st Conference of the Parties (COP21) under the

UN Climate Convention. Besides climate mitigation, the Paris Agreement also contains clear commitments and obligations for adaptation. Each party is obliged to set up an adaptation planning process and to implement the adaptation measures.

The focus of health adaptation to climate change at global level has been on strengthening health systems to better manage its impacts (WHO, 2020, 2015).

Climate resilient health care facilities are those that are capable to anticipate, respond to, cope with, recover from and adapt to climate-related shocks and stress, so as to bring ongoing and sustained health care to their target populations, despite an unstable climate (WHO, 2020, 2015).

Figure 4-3 illustrates the important dynamics affecting the climate resilience of health care facilities. It builds upon the IPCC concept of risk as a function of hazards, vulnerabilities and exposures. it depicts how hazards, in the form of a sudden event (a shock, such as a storm or sudden flood), or a slow-onset event (a stress, such as a drought, sea-level rise, or high volume of cases from a climate-related disease), will reduce the health care facility's level of performance and capacity, through a combination of impacts on key facility elements.

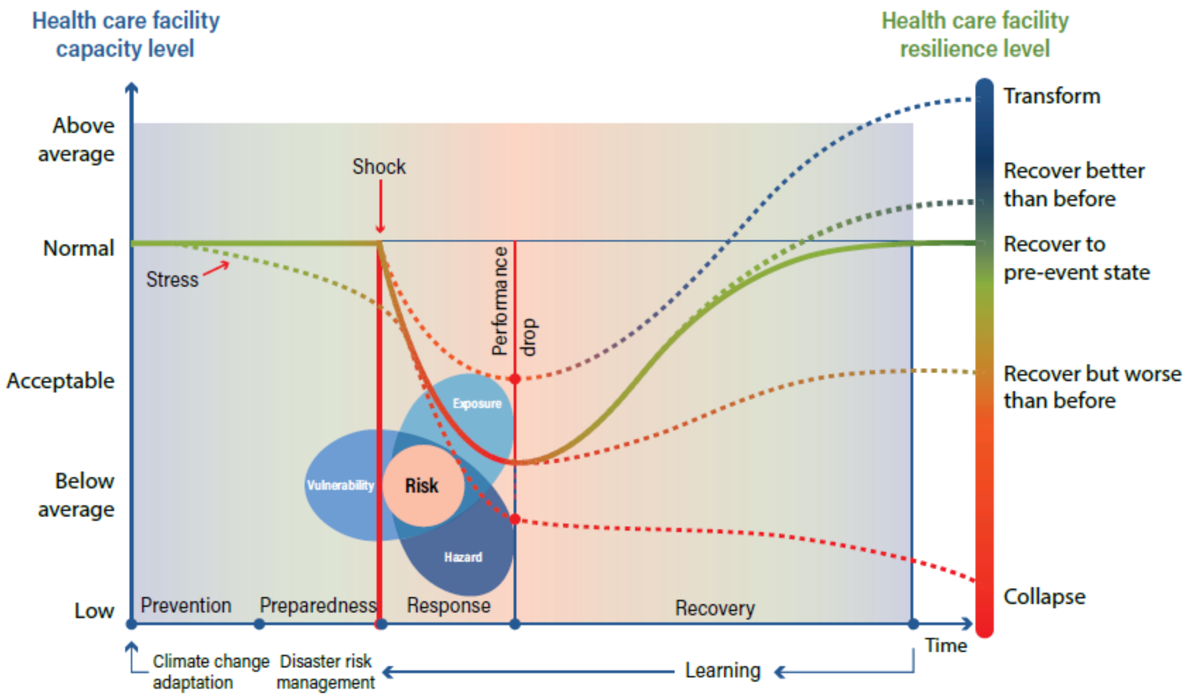

Figure 4-3. Health care facility performance and capacity level as a function of time indicating different levels of climate resilience in health care facilities. Source: WHO (2020).

The four key facility elements / fundamental requirements for providing safe and quality care in the context of climate change concern (WHO, 2020):

- Health workforce: adequate numbers of skilled human resources, with decent working conditions, empowered and informed to respond to these environmental challenges;
- Water, sanitation, hygiene and health care waste management: sustainable and safe management of water, sanitation and health care waste services;
- Energy: sustainable energy services;
- Infrastructure, technologies and products: appropriate infrastructure, technologies, products and processes, including all the operations that allow for the efficient functioning of a health care facility.

WHO Regional Office for Europe published in 2008 guidelines for heat-health action plans, including eight core elements for their successful implementation (WHO Regional Office for Europe, 2008):

- Lead body and interdisciplinary cooperation;
- Use of accurate and timely heat-health warning and alert systems;
- Heat-related health information and communication of heat risks;
- Reduction in indoor heat exposure;
- Particular care for vulnerable population groups;
- Preparedness of the health and social care system;
- Long-term urban planning and building sector;
- Surveillance, monitoring and evaluation of measures.

In a recent report by WHO Regional Office for Europe, the evidence for effective prevention has been updated for these core elements (WHO Regional Office for Europe, 2021).

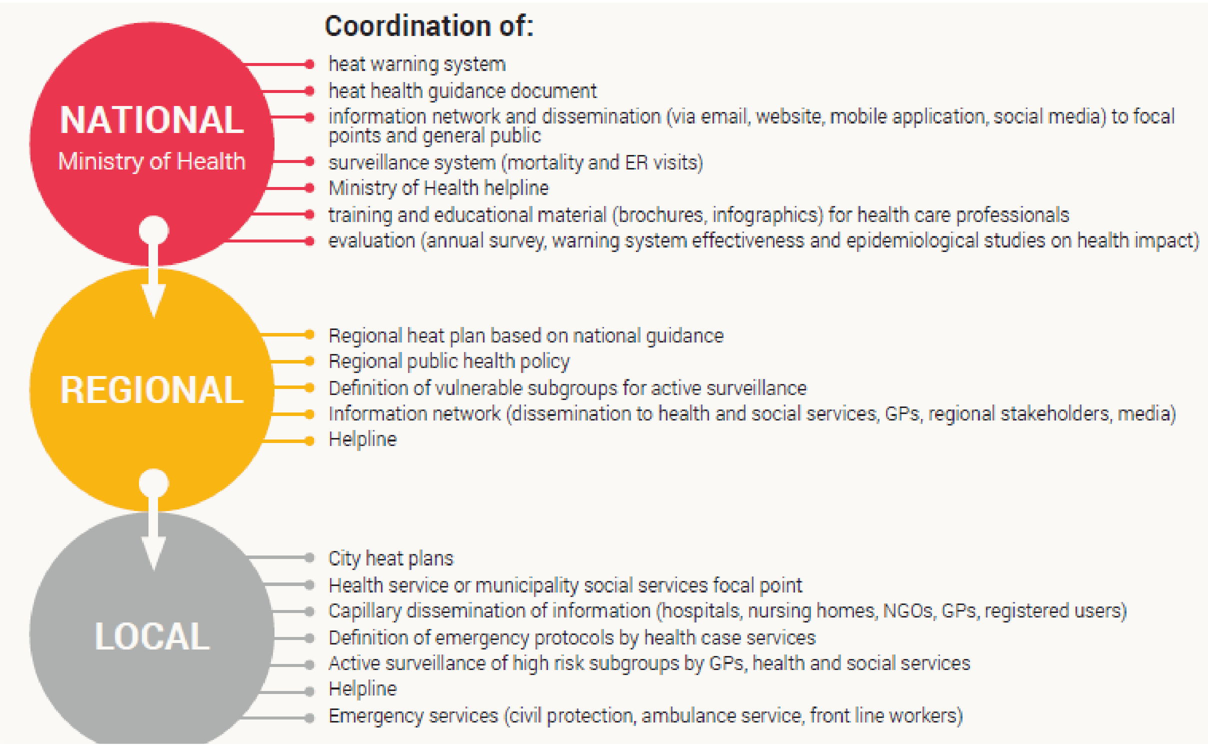

Figure 4-4 Different levels of the implementation of a heat plan. Source: WHO Regional Office for Europe (2021).

A Health National Adaptation Plan (HNAP) is defined by the WHO as a plan developed by a country's Ministry of Health as part of the national adaptation plan. HNAP development is critical for: ensuring prioritization of action to address the health impacts of climate change at all levels of planning; linking the health sector to national and international climate change agendas, including an increased emphasis on health co-benefits of mitigation and adaptation actions in other sectors; promoting and facilitating coordinated and inclusive climate change and health planning among health stakeholders at different levels of government and across health-determining sectors; and enhancing health sector access to climate funding. Six quality criteria for the successful implementation of HNAPs concern leadership and enabling environment, cross-sectoral coordination and policy coherence, comprehensive coverage of climate-sensitive health risks, comprehensive coverage of adaptation options and actions, resourcing, monitoring, evaluation and reporting (WHO, 2021a).

4.2.2 European level

On 24th February 2021, the EU strategy on climate adaptation "Forging a climate-resilient Europe – the new EU Strategy on Adaptation to Climate Change"[1] was adopted. The Strategy has four principle objectives: to make adaptation smarter, swifter and more systemic, and to step up international action on adaptation to climate change.

Smarter adaptation: Adaptation actions must be informed by robust data and risk assessment tools that are available to all – from families building homes, businesses in coastal regions and farmers planning their crops. To achieve this, the strategy proposes actions that push the frontiers of knowledge on adaptation so that we can gather more and better data on climate-related risks and losses, and enhance Climate-ADAPT as the European platform for adaptation knowledge.

Faster adaptation: The effects of climate change are already being felt, and so we must adapt more quickly and comprehensively. The strategy therefore focuses on developing and rolling out adaptation solutions to help reduce climate-related risk, increase climate protection and safeguard the availability of fresh water.

More systemic adaptation: Climate change will have impacts at all levels of society and across all sectors of the economy, so adaptation actions must also be systemic. The Commission will continue to actively mainstream climate resilience considerations in all relevant policy fields. It will support the further development and implementation of adaptation strategies and plans at all levels of governance with three cross-cutting priorities: integrating adaptation into macro-fiscal policy, nature-based solutions for adaptation, local adaptation action.

Stepping up international action for climate resilience: The EU will increase support for international climate resilience and preparedness through the provision of resources, by prioritising action and increasing effectiveness, through the scaling up of international finance and through stronger global engagement and exchanges on adaptation.

The European Environment Agency (EEA) supports the development and implementation of adaptation policies in Europe, the evaluation of EU policies and the development of long-term strategies for adaptation and disaster risk reduction by providing relevant information. This information (observations, projections, indicators, studies) focuses on climate change, impact, vulnerability and adaptation measures in Europe (EEA, 2021, 2020a, 2020b, 2020c, 2019). The European Climate and Health Observatory[2], an online platform that provides easy access to a wide range of resources about climate change and health, was launched recently. The Observatory is a joint project of the European Commission, the EEA and other contributors, which is hosted on Climate-ADAPT by the EEA. It is the first concrete deliverable of the European Commission's new EU Strategy on Adaptation to Climate Change.

In March 2013 a joint briefing by EEA and the Lancet Countdown, highlighted key health impacts from climate change as well as opportunities to reduce climate-related health risks through adaptation policies aligned with mitigation actions (EEA and Lancet, 2021).

The European Centre for Disease Prevention and Control (ECDC) focuses principally on adaptation actions concerning air-, food-, vector- and water-borne diseases. It evaluates the risks and vulnerabilities in Europe and assesses adaptation measures.

The EC is not only focusing on Member States, but also on local governments. In 2014, the European Commission launched Mayors Adapt with the aim of engaging cities and towns to take action on climate adaptation. Mayors Adapt was a parallel initiative to the Covenant of Mayors on mitigation. Both initiatives merged in 2015 to stimulate an integrated approach around climate and energy action.

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[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:82:FIN

[2] https://climate-adapt.eea.europa.eu/observatory

In 2017, this resulted in the "Covenant of Mayors for Climate and Energy". Local governments that sign this Covenant commit to reducing CO_2 emissions by at least 40% by 2030 (EU 2030 Strategy) and to adopting an integrated approach to climate change mitigation and adaptation. They also ensure that their citizens have access to sustainable, safe and affordable energy.

4.2.3 National, federal and regional levels in Belgium

In the Belgian federal system, responsibilities and policy-making powers regarding climate change are shared between the Federal State and the three Regions, each entity sets up its own priorities and objectives within the scope of their powers. There are several ministries in Belgium responsible for climate change: Federal Public Service Health, Food Chain Safety and Environment (FPS-Health), Department of Environment (Flemish Region), Wallonia Agency for Air and Climate (Walloon Region) and Environment Brussels (Brussel Capital Region). The National Climate Commission (CNC/NKC) is the national coordination mechanism, together with the International Environmental Policy Coordination Committee (CCPIE/CCIM) and the Coordination Group Greenhouse Effects (CGBKE).

Adaptation measures are defined in different adaptation plans, below we give an overview of the plans of importance in this study. The health-related adaptation measures are mentioned throughout the report.

The Belgian National Adaptation Plan 2017-2020 (NAP) contains specific adaptation measures to be taken at national level to improve cooperation and to develop synergies between the federal and regional entities (NAP, 2017). A national platform for information concerning climate adaptation is online[1] (measure 3 in NAP). It contains general information, policy information, library and dedicated sections for various sectors (e.g. health sector) where the impact and vulnerabilities and adaptation measures are briefly described.

The federal contribution to the NAP formulates measures for transport, crisis management as well as transversal issues (FPS .BE, 2017).For the Flemish Region, the Flemish Adaptation Plan 2021-2030 (Vlaams Adaptatieplan 2021-2030, VAP) aims to further strengthen Flanders' resilience to the effects of climate change and to adapt to the expected effects. The plan is currently under revision.

For the Walloon Region, the Air-Climate-Energy Plan 2030 (Plan Air Climat Energie à l'horizon 2030, PACE2030) as well as the Walloon Energy Climat Plan (Plan wallon Energie Climat, PWEC) contain different adaptation measures (SPW, 2019, 2011). The Walloon Environment & Health Plan (Plan Environnement et Santé, ENVIeS) evaluates health effects from different environmental stressors and formulates some climate-related actions (SPW Environnement-santé, 2019).

For the Brussels Capital Region, the Air-Climate-Energy-Plan (Plan Air Climat Energie Bruxellois, PACE) describes concrete adaptation measures (BE/LB, 2016).

4.2.4 Local level

The results of climate change depend on the local situation, hence climate adaptation must be tailored to the local needs and must be implemented at the local level. A vast majority of Belgian cities and municipalities dispose of an energy and climate action plan. Many local governments were triggered by the aforementioned EU Covenant of Mayors for Climate & Energy, that has been signed by more than 80% of the Belgian cities and municipalities. The local communities are further assisted by the regional authorities with the initiatives described below.

For Flemish communities the Flemish Department of Environment launched the initiative Burgemeestersconvenant[2]. The website has an adaptation toolbox containing information on local adaptation measures (heat, flooding, drought, etc.), good practices, available tools, financing possibilities, links to relevant websites. Furthermore, AZG developed a detailed guideline specifically

[1] https://www.adapt2climate.be/?lang=en

[2] https://www.burgemeestersCovenant.be/klimaatadaptatie

aiming at the implementation of local heat-health plans by local governments[1].

In Wallonia SPW l'Energie et le Climat dans ma commune provides through the Convention des Maires support for local authorities to develop a sustainable energy and climate action plan. The POLLEC (POLitique Locale Energie Climat) program[2] helps to implement energy and climate projects at the local scale, they provide subsidies for municipalities both for human resources as well as for the development and/or implementation of mitigation and adaptation investments. The Walloon Agency of Air and Climate (AwAC) developed the "Adapte ta commune" toolkit[3] for municipalities in order to assess the local climate change impact. The diagnosis is based on the completion of a questionnaire (on land use planning, health, agriculture, energy, water resources, woods, biodiversity and tourism).

Finally, in the design and implementation of the plans local authorities are often assisted by the provinces and regional intercommunal associations.

4.3 VULNERABILITY OF PEOPLE TO CLIMATE CHANGE IMPACTS

Vulnerability assessments have been carried out at the federal level as well as for the three regions (BE/LB, 2012; dOMG, 2011; SPW-AwAC, 2011; Technum, 2013).

Within the SCORCH project with respect to heat exposure four categories of vulnerable people were identified: age, environmental factors, medical factors and social factors (Vanderplanken, 2021). These categories also apply for many other climate-related health effects.

Age is considered as a risk factor for heat, both the young and elderly are more vulnerable to heat. Amongst the environmental factors are geographical risk factors such as living close to a river (increased risk for fluvial flooding), in a city (increased risk for heat, pluvial flooding). Another environmental risk is exposure to air pollution, this can exacerbate the effects of heat or pollen activity.

Several medical factors can increase people's vulnerability to climate-related health effects such as people suffering from chronic or pre-existing illness (both physically and mentally), people who are dependent on others (hospitalized, limited mobility), people who use certain medication or abuse substances, and pregnant women.

Finally, social factors can also increase someone's vulnerability, these include people without a social network, people living in poor housing conditions and people who do not have access to an outdoor area. But also people physically active during the day either for work or for leisure (music festival, sports activity, …) are at higher risk. Also, ethnic minorities, migrants and tourists can be considered as a vulnerable group as they are not familiar with local conditions and do not understand nor speak the local language. Finally, homeless people are vulnerable because of their living conditions, and lack of access to infrastructure, information and health care.

4.3.1 Social aspects of vulnerability to climate change impacts

The SECLIM study evaluated the social aspects of vulnerability to climate change impacts, in particular extreme heat and flooding (De Ridder et al., 2020). Both have health effects: heat has a direct impact on human health, and in the case of flooding it is often the mental impact of e.g. a flooded home that may affect health most. Heat and flooding often cause worse impacts for vulnerable groups, such as the elderly, lone-pensioner households, single-parent households, the unemployed, those with a lack of higher education, those being of non-European or of Eastern European origin, and recipients of social benefits, to mention a few. Different dimensions of vulnerability tend to cluster in individuals

[1] https://www.warmedagen.be/sites/default/files/atoms/files/Finaal_mei_2018_leidraad_warme_dagen_lokale_besturen.pdf

[2] http://lampspw.wallonie.be/dgo4/conventiondesmaires/appels-pollec

[3] http://lampspw.wallonie.be/dgo4/conventiondesmaires/outil-adapte-ta-commune

and reinforce each other, highlighting the intersectional character of vulnerability.

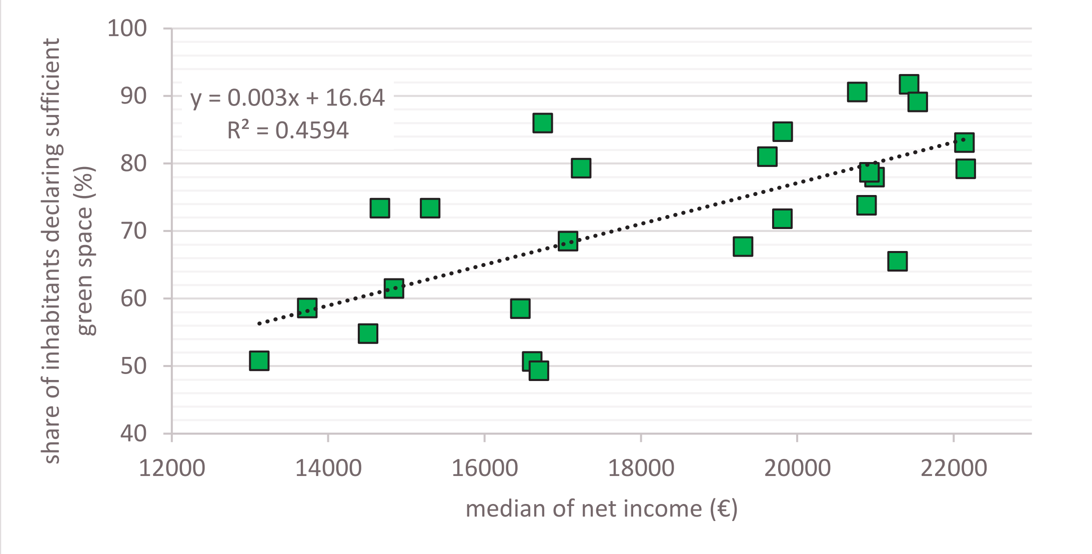

Figure 4-5. Amount of urban green space as a function of income in different city quarters of Ghent. Based on data presented in the SECLIM report (De Ridder et al., 2020; see their Section 7).

An important element in understanding vulnerability to climate change impacts is related to the fact that adverse climate conditions often occur precisely in those areas that are inhabited by vulnerable populations. As an example, densely built city quarters, which typically are home to more vulnerable people, generally also exhibit a higher risk for excessive heating and flooding. As an illustration of this, the distribution of green space abundance in cities is often positively correlated with income (Figure 4-5). In terms of health impacts this access to urban green space may be important, given e.g. that Venter et al. (2020) find that one urban tree has the potential to mitigate additional heat exposure of one heat-sensitive person by a day.

Similarly, based on data provided by Eurostat, the SECLIM study found that considerably more people from the bottom 20% of incomes live in houses that are too hot in summer than is the case for the upper 20%, especially those living in towns, suburbs and cities (De Ridder et al., 2020).

Not only are vulnerable people often more sensitive and more exposed to climate extremes and the associated health impacts; they generally also have a more limited adaptive capacity, which may be related to income level (lacking the means) or the ability to speak the official language.

Poor social networks have been specifically identified as a factor increasing vulnerability, as isolated people are less likely to receive information and help (EEA, 2018). Social isolation even increases the risk of death as a result of extreme weather events. Generally, people living on their own tend to be more vulnerable during heatwaves; 92 % of the 2003 heatwave victims in France lived alone (Poumadère et al., 2005).

4.3.2 Mapping of vulnerable people

A vulnerability mapping can be done at the level of the statistical sector identifying neighbourhoods with a population at higher risk of climate-related exposure or vulnerability. Various publicly available datasets provide information for every statistical sector in Belgium. The following parameters, published by Statbel and often based on the census of 2011, have been used in a project VITO carried out for AZG:

- Population density;
- Young children (number of inhabitants younger than 5 years per km²);
- Elderly people at home (number of inhabitants between 65-85 years per km²);
- Elderly people at home (number of inhabitants older than 85 years per km²);

- People living alone (number of singles per km²);
- Low income (deviation median income, number of job seekers);
- Housing quality (residents living in dwellings built before 1980 per km²).

The data were converted to a fixed scale and combined to derive a vulnerability index between 0 and 10 per statistical sector, more information on the methodology can be found in (Hooyberghs, 2018). Figure 4-4 shows the vulnerability map for all statistical sectors of Flanders and Brussels.

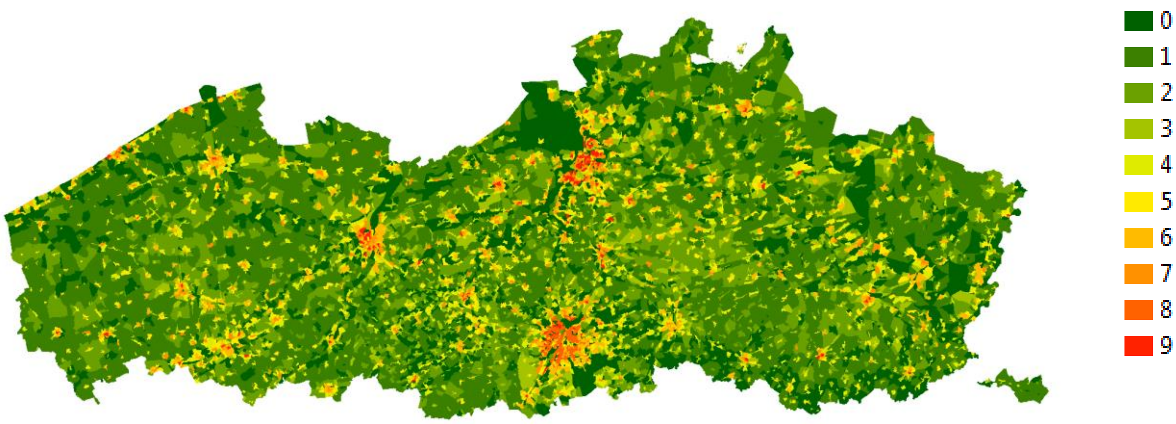

Figure 4-6. Vulnerability level of statistical sectors of Flanders and Brussels. Source: Hooyberghs (2018).

The resulting maps are working tools for regional and local administrations and authorities to take targeted measures. They can be combined with heat stress maps in order to create heat impact maps, as discussed in section 5.1.3.1.3. In section 9.2.7.1 we discuss the combination of the vulnerability maps with flooding hazard maps.

We note that for healthcare institutions and locations for vulnerable people (schools, childcare, …) data on the exact location of the buildings is available.

For other vulnerable groups, such as chronically ill people or people with pre-existing conditions or psychiatric illness, pregnant women, etc. information is not publicly available.

We note that similar maps can be made for Wallonia, based on data that are publicly available[1].

[1] https://geoportail.wallonie.be/home.html; https://sociaal.brussels/; https://statbel.fgov.be/en; https://www.census2011.be/censusselection/selectionNL.html

5. HEALTH EFFECTS FOR THE GENERAL POPULATION

An online survey, which was spread among several types of institutions in the health care sector (for more information, see Appendix A) posed a question on the concern of several types of climate risks for the general population. Table 5-1 includes the survey responses, by community, indicating the concern that health care institutions have for these climate risks. We note that this is a subjective question which can be influenced by one's knowledge on the subject. The perceptions are often based on personal experience and do not take into account future climate-related risks that are currently not causing health problems. Hence the answers to this question should not be interpreted as the actual risk for the general or patient population (Anonymous, 2021b). The respondents are most worried by the impact of heat waves and heat-related diseases, this is consistent with the interviews that were conducted with actors in the health care sector (Anonymous, 2021a).It can be noted that opinions across the communities are more or less consistent with one another, though actors in the Walloon and Brussels Capital Regions are generally less concerned in comparison to the actors in the Flemish Region. The strongest differences are noted for extreme weather conditions and mental health impact. Respondents had the option to add additional concerns not included in Table 5-1; about 1 in 5 respondents cite drought and water shortages as a concerning risk related to climate change.

Table 5-1. Online survey results for the question 'How worried are you about the following climate risks in terms of their impact on the health of the general population?'

	Not worried	Rather not worried	Rather worried	Worried	I don't know
Heat waves and heat-related diseases					
Flemish Region	0%	5%	36%	59%	0%
Walloon & Brussels Capital Regions	0%	12%	36%	52%	0%
Vector-borne diseases (e.g. Lyme, TBE, tropical mosquitoes, etc.)					
Flemish Region	8%	30%	45%	14%	3%
French & GGC/Cocom	20%	32%	32%	16%	0%
Extreme weather conditions (e.g. heavy rain, flooding, heavy wind, storm, etc.)					
Flemish Region	2%	22%	34%	42%	0%
French & GGC/Cocom	4%	36%	40%	24%	0%
Pollen, allergies or respiratory diseases					
Flemish Region	0%	33%	47%	19%	2%
French & GGC/Cocom	4%	44%	28%	24%	0%
Mental impact (fear, insecurity, etc.)					
Flemish Region	2%	35%	40%	20%	3%
French & GGC/Cocom	16%	40%	12%	28%	4%

Differences in risk perception between types of institutions were minimal. It was noted that general and academic hospitals were generally more worried about the impact of vector-borne diseases and extreme weather conditions, in comparison to other types of institutions.

Below we describe the literature on these climate risks and their health effects in the general population, as well as opinions from the interviews with the health care sector.

5.1 HEAT-RELATED HEALTH EFFECTS

In temperate climate zones, like Belgium, heatwaves claim more victims than any other weather-related disaster (Borden and Cutter, 2008; WMO, 2014). Increased morbidity and mortality is observed especially in vulnerable population groups such as the elderly, young children, people with chronical illnesses or pre-existing conditions[1]. But also outdoor workers and people with low socio-economic status are more at risk. Health effects due to heat exposure can take different forms. Figure 5-1 shows the severity of the health effects with mild effects at the bottom and more severe effects towards the top. The surface of each layer indicates which part of the population suffers from it. This figure is taken from a study of (Künzli et al., 2010) and represents health effects due to the stressor air pollution but is applicable to the stressor heat too. The health impact of the different layers appeal to different lines of the healthcare system. While mortality and hospitalization present the tip of the iceberg, it is important to have an idea of the less severe health effects in order to take adaptation measurements at the different levels.

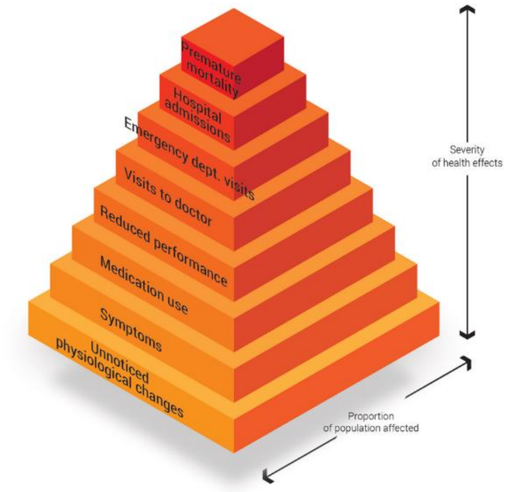

Figure 5-1 Pyramid of health effects due to environmental stressors. Source: Künzli et al. (2010).

5.1.1 Current situation

5.1.1.1 Mortality

In the period 2000-2020, the highest heat-related excess mortality in Belgium has been reported for the years 2003, 2006, 2010 and 2020, each of these with between 1500 and 1800 heat related death (Bustos Sierra et al., 2019a and as reported by Sciensano[2] (for 2020)). While all these years were characterized by heatwave episodes, the heat-mortality causality is not always very clear. For instance, the hot summer of 2018 did not cause excess mortality, which has been attributed to a very high influenza related mortality in the preceding winter (Nielsen et al., 2019). The year 2019 with extraordinarily high temperatures (exceeding 40°C) yielded 'only' 716 heat victims[3]. In 2020 the heat wave of August presented an excess mortality of exceptional magnitude in the context of the COVID-19 epidemic, affecting elderly people who had already been strongly affected by the epidemic. The mortality impact of heatwaves is often minimized by invoking the "harvesting" phenomenon, i.e., the displacement of mortality by days or weeks. However, several studies show that the remaining life expectancy of heat victims may amount to 6-8 years (Bosello and Schechter, 2013; Sanchez Martinez

[1] https://www.sciensano.be/en/projects/health-environment-and-susceptible-populations

[2] https://www.sciensano.be/nl/pershoek/aanzienlijke-oversterfte-tijdens-de-hittegolf-van-augustus-2020#:~:text=In%20en%20vlak%20na%20de,dan%2065%20jaar%20(742%20bijkomende; https://www.sciensano.be/fr/coin-presse/une-surmortalite-importante-durant-la-canicule-du-mois-daout-2020 (values pertain to 5-20 August 2020 and not to the entire summer)

[3] https://www.sciensano.be/nl/pershoek/3-perioden-van-oversterfte-tijdens-de-zomer-van-2019

et al., 2015; De Ridder et al., 2016).

In Belgium, accounting for urban effects is particularly important given the large share of people living in cities and towns. Considering mortality data for Belgium presented in Bustos Sierra et al. (2019a) by region, it emerges that Brussels has a higher excess mortality percentage than the Flemish and Walloon Regions. Several other studies also report higher heat related mortality rates in cities (Vandentorren et al., 2004; Gabriel and Endlicher, 2011; Dousset et al., 2011). This has been attributed to the urban heat island temperature increment as well as the high concentration of vulnerable people in cities, such as elderly and/or isolated people, or people living in poor housing conditions (Keller, 2015). For instance, in a study on Antwerp (Stevens et al., 2015), clear correlations were found between the spatial patterns of the number of heatwave days and the spatial distribution of elderly stay facilities (Figure 5-2).

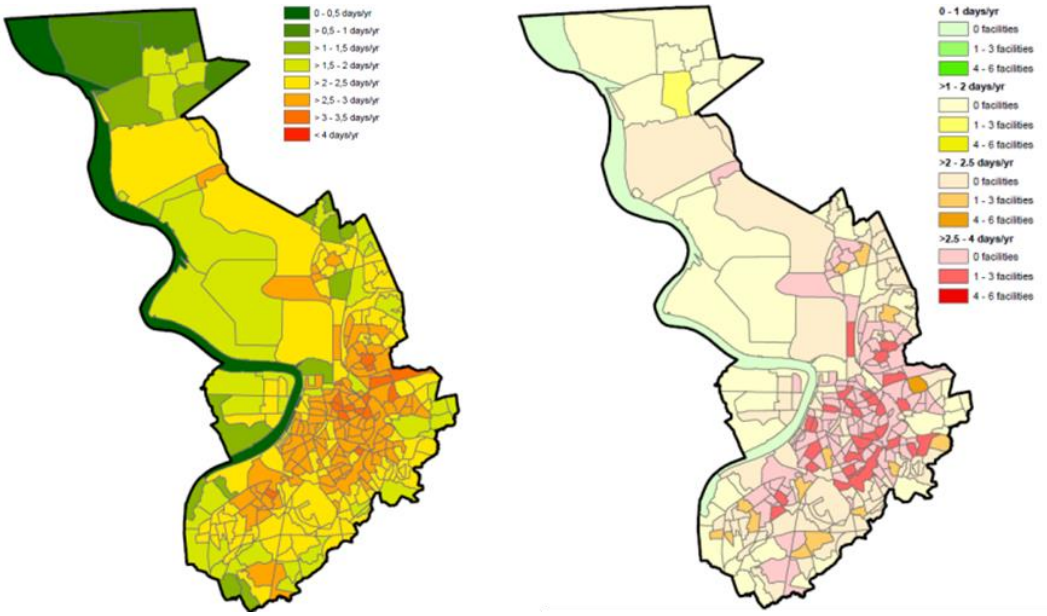

Figure 5-2. Spatial pattern of the number of heatwave days (left) occurring in Antwerp (period 1986-2005) versus the number of elderly stay facilities per statistical unit that are exposed to a given number of heatwave days (as in the legend). From Stevens et al. (2015).

A recent study found a significant effect of temperature on mortality above a city-specific threshold, both in Antwerp (25.2°C) and in Brussels (22.8°C). Adjustment for air pollution, especially ozone, attenuated the effect. It was estimated that per 1°C increase in the temperature above these thresholds, the mortality increases with 4.9% in Antwerp and with 3.1% in Brussels. During the study period, 1.5% of the deaths in Antwerp and 3.5% of the deaths in Brussels could be attributed to the effect of heat (De Troeyer et al., 2020).

In an ongoing study of CenStat-UHasselt for AZG (Flemish Agency Care and Health) a retrospective analysis of the impact of heat on cause-specific mortality is made for Flanders, data for the years 2000-2017 are being used (Faes, 2020). They determined reference temperatures for minimal mortality (cardiovascular, respiratory, renal). In the report, relative risks are derived for mortality (all causes, cardiovascular and respiratory) for different lag times, usually between 0 and 3 days. The report is not available at the time of writing, but some conclusions from the preliminary report are of interest in the context of climate change and an ageing population:

- The largest effects of heat on mortality are observed for the 85+ age group, to a lesser extent for the 75-84 age group and for respiratory mortality also for the 65-74 age group.
- Lag periods are longer for respiratory mortality compared to cardiovascular mortality.
- Effects of socio-economic status are significant: Faes et al. (2020) observed lower heat-related mortality according to higher net income of the municipality of residence.
- The effects of heat-related mortality are higher in urban areas than in rural areas.

In the framework of the ongoing HEASP project (study in nine Belgian cities, 307,859 deaths from natural causes included, 2010-2015, Sciensano), a first investigation of the short-term exposure to temperature and all-cause and cause-specific mortality showed that when considering a cumulative effect of temperature over 21 days before death, both heat and cold were associated with increased mortality risks from all causes. When considering a cumulative effect of temperature over 7 days before death, the effect was lower for cold temperature but higher for hot temperature. The shapes of the cause-specific related mortality (ischemic heart disease, cerebrovascular, other cardiovascular, chronic obstructive pulmonary disease, other respiratory, and other natural) showed various patterns with a clear effect of heat on mortality due to ischemic heart diseases. Preliminary results have also shown a significant relative effect modification of the associations by age and health status for chronic diseases such as diabetes.

5.1.1.2 Hospitalization

Evaluations of heat-related morbidity effects are less frequent and more uncertain. Often there is focus on a very limited set of outcomes, which makes studies difficult to compare. High ambient temperatures cause heat-related illnesses such as heat exhaustion and heat stroke, aggravate several common cardiovascular and pulmonary conditions (Borden and Cutter, 2008), potentially leading to an increased number of hospital admissions and ambulance calls (Li et al., 2015; Wondmagegn et al., 2019). Heat has been associated with enhanced hospital (emergency department) admissions (Ordon et al., 2016; Isaksen et al., 2015, Liss et al., 2017; Fuhrman et al., 2016).

Several European studies reveal that heat related hospital admissions of **elderly persons** are high, particularly during the first heatwave occurring in a season, but they also identify the particular vulnerability of **children** and **adolescents**, caused by enhanced exposure associated with the timing of organized sports during summertime (Ghirardi et al., 2015; Josseran et al., 2009; Kovats et al., 2004; Mastrangelo et al., 2007; Michelozzi et al., 2009; van Loenhout et al., 2018). In most of these studies hospital admissions during heat waves are related to health complaints such as dehydration, hyperthermia, hyponatraemia, malaise, renal diseases, respiratory diseases. However, they are **not associated with cardiovascular diseases**, whereas cardiovascular diseases are a cause of increased mortality during hot weather. This discrepancy suggests that cardiovascular problems are acute and lead to mortality before hospitalization, or that the symptoms are not timely recognized (Kovats et al., 2004).

This discrepancy has also been observed in a study carried out in 10 Flemish elderly homes (Van den Wyngaert, 2019). A case-crossover analysis showed an increase of mortality during heat wave days while the number of hospitalizations did not change significantly. The authors suggest different hypotheses for the contrasting patterns of mortality and morbidity effects. It is possible that circulatory disease leads to a sudden death, another possible explanation is the will of some elderly to quit hospitalization. Significant differences have been observed between the elderly homes, this might be due to different policies, housing characteristics, locations, …

Based on newspaper reports regarding extra emergency department admissions, the SECLIM study very roughly estimated an additional 2000 daily emergency department admissions occurring in Belgium on extremely hot days, mostly concerning elderly persons, who generally sought help for dehydration and cardiac and respiratory difficulties (De Ridder et al., 2020).

5.1.1.3 General practitioners' visits

Most research on the effect of heatwaves on morbidity is based on hospital and emergency care data, research using primary data is limited. However, it is important to include these since data from primary health care cover a broad range of the general population and a broad range of disease severity including mild disease and symptoms.

Alsaiqali et al. (2021) used the Intego database (see section 3.6) in a time-stratified case-crossover analysis to study the impact of heatwaves (RMI definition) on general practitioners' visits in Flanders.

They found increased occurrence of heat-related morbidities such as heat stroke, dehydration, orthostatic hypotension on a heatwave day compared to a non-heatwave summer day. For cardiovascular morbidity there was an increased risk of stroke, for respiratory morbidity heatwaves were associated with a decreased risk for respiratory infections. In the study the time stratified method was used to select a reference day for a heatwave day, this reference day was in the same month and day of the week of the heatwave day. This might influence the results as from hospitalization data from van Loenhout et al. (2018) it appears that already from a daily maximum temperature of 21 °C there is an increase in emergency department admissions. One can expect this increase also in general practitioners' visits. Further research is needed to also assess the effect of lag times, definition of heatwave, …

5.1.1.4 Medication use

Several types of medication can pose an increased risk during prolonged hot weather, the WHO has compiled a list (WHO Regional Office for Europe, 2011). Diuretics help drain the fluid in the body by causing it to be excreted, in this way salts and minerals in the urine also leave the body, disturbing the salt balance. This is potentially dangerous, especially if the kidney function is already impaired. In addition, many people with conditions are less able to feel their thirst. This increases the risk of dehydration, kidney function disorders and insufficient temperature control due to reduced sweating. A disrupted fluid balance also poses a possible danger of overdose in case of dehydration, especially in the case of medicines with a narrow interval. If there are problems with bowel movements, it is important to drink enough. Both diarrhoea and constipation, as well as the use of laxatives, can lead to fluid deprivation. In addition to medicines that directly affect the body's heat regulation, there is also a risk of overdosing with medicines that are taken according to a prescription because dehydration symptoms may occur. This problem is particularly acute for medicinal products with a narrow therapeutic range (where the level of active substance in the blood must remain within narrow limits). A small increase in concentration can then lead to overdose or a toxic blood level. Medication should be stored and transported at temperatures below 25°C (or in the refrigerator if indicated). Higher temperatures may reduce the effectiveness of the medication higher temperatures may reduce the effectiveness of the medication.

Patients with mental disorders are more sensitive to high temperature exposures (Almendra et al. 2019). Antipsychotics can interfere with regulatory temperature functions and decrease the body's capacity to shed heat, by adversely affecting the parasympathetic nervous system, i.e., by suppression of perspiration. This, in turn, can induce alterations in pharmacokinetics of other psychotropic drugs, increasing the risk of drug toxicity (Martin-Latry et al., 2007). In addition, a reduced autonomic nervous system functioning owing to antipsychotic medicine intake has been found to contribute to heat stress and development of depression, especially in the elderly (Chen et al. 2019). Moreover, some schizophrenic patients manifest cognitive impairment that can affect their ability to evaluate the environmental temperature and act adequately (Zhao et al. 2016).

Preliminary results from the aforementioned HEASP project also indicate that people with a prescription for diabetes medication might be at higher risk for heat-related mortality.

5.1.1.5 Adverse birth outcomes

Pregnant women are more susceptible to heat stress, Cox et al. (2016) found that in Flanders high ambient temperature may trigger premature child birth, which is not only one of the main causes for infant mortality but also affects health at later stages in life. In a recent analysis of effects of temperature on birth in Brussels, it was found that increased temperatures led to higher rates of births, preterm births and births associated with maternal hypertension (Blavier et al., 2021).

5.1.1.6 Reduced performance, sleep disturbance, unnoticed physiological changes

Hot weather affects cognitive abilities resulting in reduced alertness, perception and attention. studied cognitive functioning in young adolescents and found that reaction times in a Stroop test increase above as well as below an indoor temperature of 22°C – 23°C (Cedeño Laurent et al., 2018). The Belgian Traffic Institute VIAS calculated that the number of seriously injured and deadly accidents increases by 15 % during a heatwave day compared to a normal day (VIAS magazine, 2018). There are different reasons for this increase, first there are more pedestrians and cyclists on the road. But due to the heat car drivers are more tired and get easily agitated resulting in dangerous and impulsive driving conditions (VIAS magazine, 2018).

Sleep disturbance (in the form of increased body movements, awakenings and arousal) is found to increase with higher night-time temperatures (Obradovich et al., 2017). Although individual sensitivities and circumstances might differ, sleep loss and sleep disorders can have serious health consequences. On the short-term sleep deprivation has an impact on biological processes that affect the metabolic energy level, immune system, well-being, ... Cumulative sleep loss and disorders have been associated with an increased risk of hypertension, diabetes, obesity, depression, heart attack, stroke (Colten et al., 2006).

(Huynen et al., 2019) conducted a survey in the general population in Dutch Limburg in September 2013, in which almost half of the participants reported experiencing discomfort during the heat waves in the summer of 2013. Participants reported complaints such as sleep disturbance, fatigue and exhaustion. Another Dutch study examined the most common heat-related symptoms in the elderly living at home, which were sleep disruption (62%), fatigue (61%) and respiratory problems (29%) (Van Daalen and Van Riet, 2010).

5.1.1.7 Mental health

Exposure to extreme heat is known to affect mental health: increased temperatures lead to poorer sleep quality, a lack of sleep causes the body and mind not to recover, and it might delay or disturb a patient’s recovery process. Exposure to extreme heat has been associated with a higher incidence of mood disorders, attempts to commit suicide, increased aggression and violence, and overall negative consequence for mental health (Bourque and Willox 2014; Noelke et al. 2016; Thompson et al. 2018). A study conducted in Belgium by Linkowski et al. (1992) indicates that high temperatures, together with sunlight duration, is related to the probability of violent suicide. Indirectly, extreme temperatures, through their adverse impacts on, e.g., crop yield) or health impairment can lead to enhanced mental health problems including increased suicide rates (Rigolon et al., 2021) (Berry et al. 2010, Carleton, 2017). Vida et al. (2012) studied the relationship between temperature and the number of emergency admissions for mental and psychosocial problems. The results show that the number of emergency admissions increases with increasing temperature (and humidity) from 20 °C, especially in urban areas. One should note that the associations between extreme weather outcomes and human behaviour are complex, there are many confounding factors (Vida et al., 2012). Patients with mental disorders are at risk, as they are more sensitive to high temperature exposures and that medication can interfere with their system functioning. I has been noted that patients in psychiatric institutions experience more severe delusions or thought disorders and may experience a higher number of acute episodes (Anonymous, 2021a).

For other climate-related risks for mental health, we refer to section 5.5.

5.1.1.8 Labour productivity

High temperatures and heat waves have a negative impact on labour productivity. Although this is particularly the case for outdoor work (e.g. in agriculture or construction), indoor work (e.g. office work, shops, industry) is also affected. In Belgium, the services sector, with mainly indoor work, is the largest sector in the GDP and hence it will experience a rather large loss in productivity despite its lower heat sensitivity. De Ridder et al. (2020) assessed the costs of climate change for different sectors, the sectors dealing with health and labour productivity are expected to represent the highest costs by the end of the century.

Throughout interviews as well as survey among the health care sector, the impact of high temperature and heat waves is noted for care activities indoor. (Anonymous, 2021a, 2021b) Executing these intensive activities in a warm environment, puts more strain on the personnel. This is discussed further in section 6.

5.1.1.9 Heat-related risks for vulnerable groups

Stakeholders in the healthcare sector identified excessive heat as the most important climate-related health risk (Anonymous, 2021a, 2021b). In recent years, the increase in heat-related mortality and morbidity – as evident in the data discussed previously – has indeed been noticed by healthcare workers and patients. Especially among those health care professionals working with high-risk groups. Several high-risk groups in terms of increases in temperature have been identified by stakeholders.

Elderly individuals are the most frequently cited risk group. In elderly care homes, for example, a negative health impact due to increased temperature have been evident: aside from the physical effects during the day (i.e. dehydration), it is noted that heat also effects sleep of residents or patients, thus increasing mental strain. The fact that elderly individuals are often less mobile creates additional risks since they often cannot take small preventive actions themselves (e.g. sitting in the shade).

Aside from elderly who reside in residential care, many stakeholders in the sector point to **elderly individuals still living at home** specifically as an important risk category. There are clearly more challenges in monitoring health, hydration levels, body temperature etc. among those individuals. Fatigue, caused by lower sleep quality due to heat, adds to risk of accidents at home.

Another important risk group in terms of temperature-related morbidity are patients residing in **psychiatric institutions**. This group is less able to take the appropriate small preventive actions themselves. Psychiatric individuals who require restraining at night can experience additional discomfort due to increased temperatures. There is an additional risk in terms of medication of which dosing needs to be adapted depending on temperature and hydration. This is being monitored to the best possible extent by caretakers but often requires blood testing which – in turn – causes delays in health metrics. Require adjustments in medication treating somatic symptoms have been researched more extensively than medication aimed at treating psychological symptoms. This lack of research or information causes additional risk for psychiatric patients. Psychiatric patients as well as patients with a disability often have a decreased ability to recognize when they get dehydrated, causing them not to drink sufficiently in warm and dry periods.

The treatment and exercise schedule of patients in **rehabilitation hospitals** may also be disturbed when it is too warm inside or outside to perform physically demanding activities.

Individuals with **foreign background as well as those in lower socio-economic groups** experience increased risk since it is more difficult to communicate risk levels and preventive measures appropriately. Additionally, the infrastructure of these groups is often not adequately adapted to very high temperatures.

5.1.2 Expected changes

Climate projections very consistently point towards a strong increase of both the frequency and the intensity of heatwaves (Diffenbaugh and Giorgi, 2012), which will lead to an enhanced heat exposure in the population. Taking the present/future heatwave maps (Figure 2-5) presented in Section 2.1 for the Liège area as an example, and overlaying it with population density maps, it is found that, while currently the main share of the population is on average exposed to 1-2 heatwave days each summer, this exposure will increase to 6-8 days by 2026-2045 (Bosello and Schechter, 2013; Sanchez Martinez et al., 2015; De Ridder et al., 2016). While proper population exposure maps are not available for later in the century, from Figure 2-5 it appears that urban dwellers in Liège will be exposed to 20-27 heatwave days each year, on average.

It should be noted though, that reality appears to be catching up quickly with these projections (RMI, 2020). An analysis of in-situ data for the city of Ghent (rather similar in size to Liège) described in De Ridder and Lefebre (2018-2019) and De Ridder et al. (2020) shows that over the past three years (2018-2020), the average number of heatwave days was slightly over 14 already. While this three-year period may be too short to draw any robust conclusions, it suggests that a careful monitoring of heat extremes in the coming years is warranted.

This figure also shows the enhanced exposure of urban populations: the rightmost blue stacks (4-5 heatwave days) denote the exposure of the *urban* population within the Liège domain, from which it appears these groups are already experiencing heatwave conditions that other population groups within (the rural portions of) the domain, currently in cooler situations, will only be experiencing in the coming decades (leftmost red stacks).

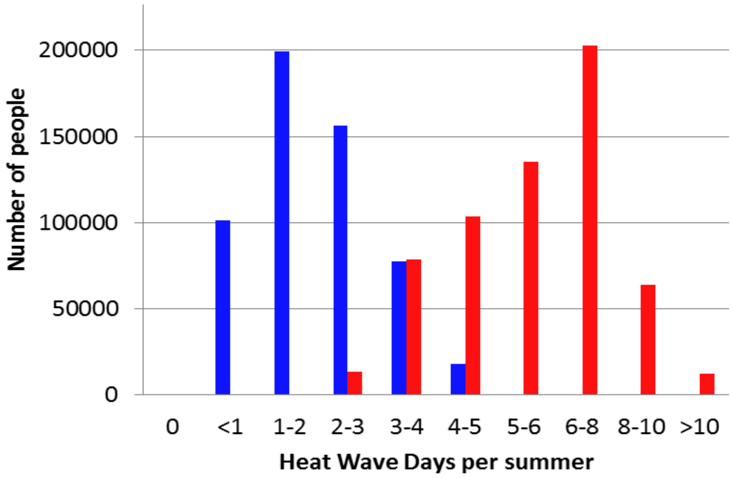

Figure 5-3. Statistical distribution of the number of persons in the Liège area exposed to a given number (horizontal axis) of heatwave days per year, for the years 1996-2015 (blue) and 2026-2045 (red) under RCP8.5. From Poelmans et al. (2018).

Periods of high heat are often characterized by high levels of UV-radiation and ozone. As mentioned in section 2.4 a slight increase in UV levels is expected due to reduced cloud cover and aerosols. However, there is a large uncertainty in this assessment due to stratospheric ozone levels. For ozone average concentrations are likely to increase while peak concentrations to decrease, as discussed in section 2.7 there is a large uncertainty coming from the emissions.

5.1.2.1 Autonomous and planned adaptation, changes in vulnerability

Adaptation includes a wide range of actions in response to climate change. One can distinguish between autonomous adaptation (or acclimatization) and planned adaptation. Autonomous adaptation occurs as a physiological and behavioural process of acclimatization to a warmer climate. Planned adaptation refers to collective and policy interventions to reduce the impact of climate change. They include surveillance and prevention programmes including early-warning systems, sharing information on behavioural strategies, new technological prevention measures.

In some European countries a decrease has been observed in the vulnerability of the population to heat or health impacts of heat: France (Fouillet et al., 2008; Pascal et al., 2018), Ireland (Pascal et al., 2013; Paterson and Godsmark, 2020), Italy (de'Donato et al., 2018), Spain (Achebak et al., 2018). Achebak et al. (2018) showed that the minimum mortality temperature increased by 0.77 °C between 2002 and 2016. The risk of cardiovascular deaths due to warm (and cold) temperatures also decreased across all age groups. In The Netherlands Folkerts et al. (2020) found that the susceptibility of humans to heat decreased over time. In the UK no decrease has been found and there is evidence that heat-related mortality may be increasing, an increase in the elderly population is expected to amplify this effect (Arbuthnott and Hajat, 2017). Parry et al. (2009) highlighted the lack of evidence on the assessment of specific adaptation options. In the projections carried out within the ClimateCost study (see also section 5.1.2) one assumed acclimatization to 0.5 °C warming every 30 years. Furthermore, acclimatization rates are region-specific. Krummenauer et al. (2019) indicates that the drivers for heat adaptation have not yet been clearly identified (Krummenauer et al., 2019). They established a generalized model considering climatic, topographic and socio-economic drivers. The model application for 500 European cities reveals a decrease in minimum mortality temperature between 27.8 °C - 16 °C for southern to northern cities. However, there are changes due to socio-economic conditions.

There are no studies available on the heat-related vulnerability in Belgium.

5.1.2.2 Non-climate related trends

In addition to climate change, other variables and long-term trends can be expected to affect the relationship between temperature and health.

Urbanization increases heat exposures through the UHI-effect (section (2.1.2)). With an average of 371 inhabitants per square meter, Belgium is one of the most urbanized countries in Europe.

High temperatures put the highest risk on elderly, chronically ill people and people with pre-existing circumstances. The ageing Belgian population is expected to increase in the future, at least until 2070. The proportion of the population aged 67 and over is estimated to increase from 16.5 % in 2018 to 22.9 % in 2070. The ageing intensity ratio, measured the proportion of 80+ population within the group of 67+, will increase from 33.9 % in 2018 to 45.6 % in 2070 (Gerkens S, 2020).

Furthermore, the health care system has to cope with an increase of chronic diseases and increasing multimorbidity amongst the Belgian population, this requires a vision on long-term care. The recent HIT-report mentions the intention to further develop home-based and community-based care (Gerkens S, 2020). The aim is to remain the patient at home for as long as possible for mental, palliative, long-term and rehabilitation care.

5.1.2.3 Mortality

The scientific consensus is that without strong levels of adaptation, climate change is bound to increase the heat-related burden of disease (WHO2021). Forzieri et al. (2017), using historic mortality statistics for Belgium together with projected temperatures under a business-as-usual scenario (RCP8.5), estimate that the number of heat related deaths in Belgium will increase from a current average of 70 persons per year (1981-2010 baseline period) to more than 2800 towards the end of the century. In comparison, all other climate hazards combined, including river floods, coastal floods, and windstorms, add up to a mere 4 casualties per year towards the year 2080 (See Table S8 In the Annexes of Forzieri et al., 2017).

Based on work by Sanchez Martinez et al. (2018), the SECLIM study (De Ridder et al., 2020) found that, under scenario RCP8.5, we could expect a heat attributable mortality of an additional 1830 per year (on average) in the period 2081-2100 compared to 1981-2010. The difference of approximately a factor 1.5 with Forzieri et al. (2017) can be explained by the fact that, while the latter account for demographic projections (increased total population and larger share of elderly persons), Sanchez Martinez et al. (2018) do not. Similar differences of about a factor 1.5 between both types of estimates have been found by Watkiss et al. (2019). From Sanchez Martinez et al. (2018) it has also been estimated that the number of additional heat related death in 2050 under RCP8.5 would amount to 962.

These mortality figures are to be put in perspective against recent observations of excess mortality. Indeed, while a proper analysis has not been conducted, the summer of 2020 claimed 1460[1] excess presumed heat-related death, which corresponds to projected excess mortality figures applying much later this century. Yet, this observed excess mortality pertains to a single year, hence robust

[1] https://www.sciensano.be/nl/pershoek/aanzienlijke-oversterfte-tijdens-de-hittegolf-van-augustus-2020

conclusions cannot be drawn from it; at the same time, such a high value is clearly a cause for concern.

With climate change, not only are summers expected to get hotter, winter periods are expected to become milder. Consequently, cold-related mortality is expected to decrease (Ballester et al., 2016).

Exposure to cold can lead to direct effects such as hypothermia, or indirect pathologies such as cardiovascular disorders (hypertension, thrombosis) or respiratory infections (influenza, pneumonia) (Ballester et al., 2016). People with pre-existing cardiovascular and respiratory diseases and the elderly are the most vulnerable (Ryti et al., 2015; Hajat et al., 2017). Currently, in temperate climates the death toll associated with winter cold still far exceeds that of death figures related to summer heat. To put things in perspective, consider the number of 152,000 death attributed to influenza in the 2017/18 winter season in Europe (Nielsen et al., 2019), compared to the death toll of 70,000 attributed to the (exceptional) European heatwave of 2003 (Robine et al., 2008).

Studies generally point to a decrease, with global warming, in the number of cold-related deaths. However, no detailed information appears to be available regarding future projected changes in cold-related mortality for Belgium. Therefore, in SECLIM (De Ridder et al., 2020), use was made of detailed projections by Ščasný et al. (2020) for the Netherlands, which has a climate and a demographic structure not too dissimilar from that in Belgium. Future cold-related excess mortality estimates were then converted to the Belgian situation, accounting among other for population differences, and mapping the specific Dutch climate scenarios to the IPCC/RCP scenarios. This exercise yielded an estimated annual decrease in cold-related mortality by 1230 units at mid-century, and a value of 1816 towards the end of the century, both under scenario RCP8.5. These figures are to be compared to the additional 962 (mid-century) and 1830 (end of century) death caused by heat, as described above. Hence, at mid-century the avoided number of cold-related death is expected to surpass the additional heat-related death; by the end of the century this situation is reversed.

Based on data presented in Bustos Sierra et al. (2019b, their Table 12) for wintertime mortality, together with climate change projections for Belgium presented in Termonia et al. (2018), one can make an alternative simple 'back-of-the-envelope' type of estimate of the expected future cold-related death per year. Bustos Sierra et al. (2019b) provide percentage excess mortality for the winter season during the period 2000-2018, together with several climate indicators. Regarding the latter, we focus on the indicator 'number of frost days', which is the number of days in a winter season that the minimum temperature descends below 0°C, and which currently amounts to around 37 days each year. The reason to focus on this particular indicator, and not the other indicators, is that Termonia et al. (2018) provide projections for it. Indeed, they project a decrease by 12 days of the number of frost days under scenario RCP4.5 at the end of the century, which corresponds relatively well with scenario RCP8.5 in 2050, as can be deduced from Figure 2-3 in the SECLIM report (De Ridder et al., 2020). Hence, the climate projections entail a decrease of the annual number of frost days from approximately 37 to 25.

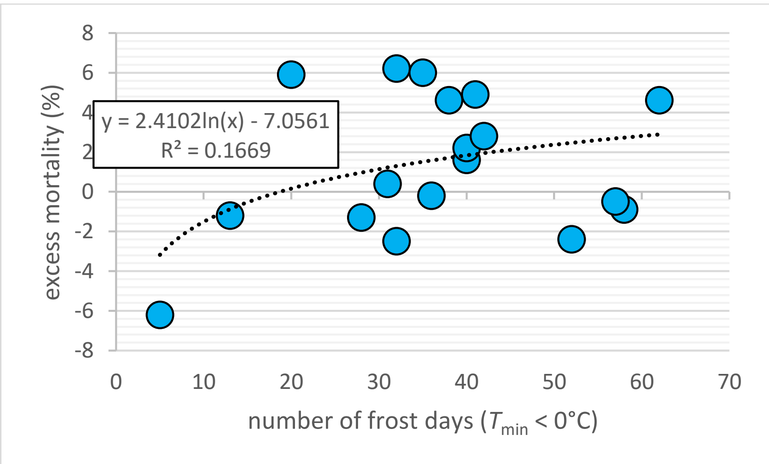

Figure 5-4. Excess wintertime mortality as a function of the number of annual frost days. Source: Bustos Sierra et

al. (2019b).

Plotting wintertime excess mortality against the number of frost days occurring in a year yields the scatter plot shown in Figure 5-4. Based on a logarithmic fit (which yields a better correlation than a linear fit), it can be deduced that the decrease from 37 to 25 frost days will induce a decrease by 0.95 percent-point of excess mortality. From the presentation in Bustos Sierra et al. (2019b) of both absolute and percentage excess mortality values – e.g. 6% corresponding to around 4000 deaths – one finds a decrease of cold-related mortality by around 630 death each year towards mid-century under RCP8.5. This is about half of the 1230 avoided cold-related death estimated above based on other studies.

It should be noted, however, that there is no conclusive consensus among experts regarding the reduced excess mortality due to milder winters. For example, Staddon et al. (2014) conclude that – although winters in our region are indeed characterized by a higher excess mortality than summer periods – there is not always a causal relationship between the intensity of the winter cold and excess mortality. Ballester et al. (2016) conclude that winter excess mortality in Belgium, together with the Netherlands and the United Kingdom, shows almost no association with winter severity. Kinney et al. (2015) also question the expected decrease in winter mortality with climate change and milder winters. Ebi et al. (2013) report that vitamin D deficiencies in winter may explain (part of) the excess mortality, because these deficiencies can lead to a reduced functioning of the immune system and therefore the incidence of infectious diseases, including influenza; the vitamin D status of the population is at least a potentially confounding factor in studies that have so far focused mainly on temperature effects. Analyses by Sciensano also show that winter excess mortality in Belgium is more strongly correlated with the occurrence of influenza than with the occurrence of low temperatures as such (Bustos-Sierra et al., 2019b).

We would like to conclude this subsection by pointing out that one should avoid considering the expected health benefits from reduced winter cold to serve as a 'compensation' for the adverse health effects of increasing summertime heat. Indeed, although the climate change related benefits from a decrease in cold-related mortality may balance the increasing trend in heat-related mortality, both require specific and different policy actions (Ščasný and Alberini, 2012).

5.1.2.4 Morbidity

Future trends in heat-related morbidity impact are less consistent than the mortality impact (WHO 2021).

Within the PESETA II-project an integrated model for the health impacts of climate change has been developed (Paci, 2014). Climate data were coupled with demographic, socio-economic and health data through exposure-response functions based on epidemiological studies mentioned above. Projections were calculated under different Special Report on Emission Scenarios (SRES) emissions scenarios (medium to high emission scenario A1B and E1 stabilization scenario) and different climate models. More details can be found in Paci (2014). The A1B and E1 scenarios use different emission data, climate models, and population estimates. The resulting global mean temperature estimates go along the RCP8.5 scenario until 2050, for the period 2050-2100 the estimates differ with RCP8.5 highest, followed by A1B and E1.

In the health impact assessment, the model assumes autonomous adaptation (by applying a shift in the threshold temperature of 0,75 °C per 30 years for impacts caused by heat stress). However, the temperature-hospitalization relationships remain unchanged, if populations acclimatize to their new average temperatures, but remain equally vulnerable to departures from average conditions. The implementation of heat-health warning systems was included. Hospital admissions are found to increase over time. It is estimated that in the 2071-2100 period in Europe, more than 170.000 hospital admissions per year will be caused by higher temperatures under the A1B scenario. This increase is mainly caused by respiratory diseases in the elderly population, also hospital admissions due to renal diseases are found to increased. In the E1 scenario the increase is estimated to be less pronounced. In the first period the expected extra morbidity is higher than in the A1B scenario (100.000 yearly hospital admissions in the 2010-2040 period), but it will be significantly lower in the last period considered. The baseline incidence of the hospital admissions is based on hospital admissions data from the European Hospital Morbidity Database[1].

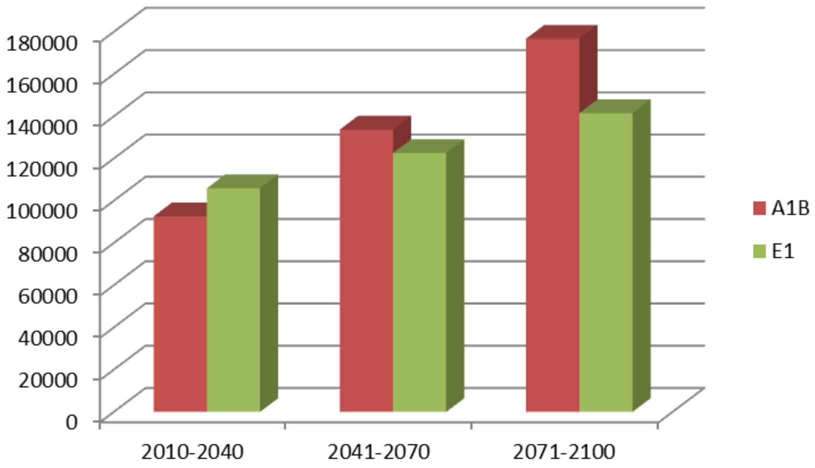

Figure 5-5. EU27 total of heat-related hospital admissions (per year). Source: Paci (2014).

There are no numbers reported for individual countries, as there are certainly differences between northern and southern countries.

For heat-related pathologies, an increase in the length of in-hospital stay has been observed in Australia, this is possibly related to an increasing disease severity (Wondmagegn et al., 2021a). The current heat conditions in Australia are not attained in Belgium currently but it gives an idea of future evolutions.

5.1.3 Current and planned measures

5.1.3.1 Data availability

5.1.3.1.1 Heat and heatwaves: monitoring and surveillance of current situation, short- and- long-term forecast

Data for Belgium

The Royal Meteorological Institute (RMI) of Belgium provides weather, climate and geophysical services, based on observations and research, for the national territory.

Weather forecasting are based on meteorological observations coming from automatic weather stations as well as the climatological network which contains of about 200 stations spread over the whole country. In the daily meteo forecast, mostly presented for the entire Belgian territory, maximum and minimum air temperatures are given. The RMI defines a national, climatic heat wave when the maximum temperature measured in Uccle reaches at least 25 degrees for at least five consecutive days, with at least 30 degrees being reached on at least three days. The same criterion is used for heat warnings, but with predicted temperatures on a provincial scale. On the RMI-website observations, forecasts as well as warnings for different meteo circumstances can be consulted. The warnings are available per province. The same information is available on the RMI meteo-app, there is the possibility to select locations for which the information is shown, the meteo-app has 584000 active users. RMI also provides SMS-services for companies and organizations. RMI provides input for

[1] https://gateway.euro.who.int/en/datasets/european-health-for-all-database/

Meteoalarm.eu[1], providing information to prepare for extreme weather, expected to occur in Europe. For Belgium the data are shown at the level of a province, we note that the colour scales used in the website are country dependent. RMI is also active on social networks with approximately 3000, 1000 and 15,000 followers on Twitter, Instagram and Facebook, respectively.

The climate projections and scenarios described in section 2 are based on the climate projections performed by RMI (Termonia et al., 2018; RMI, 2020).

The Belgian Interregional Environment Agency (IRCELINE)[2] issues heat warnings for activating the warning phase in the framework of the ozone and heat plan, for more details see section 5.1.3.2. This heat warning is based on predicted maximum temperatures for Uccle, the same alert level applies for entire Belgium. The criteria used are health-related and are not the same as the ones used by RMI.

IRCELINE has a mailing list for heat (and air pollution) related warnings, with almost 5,000 subscribers. it has 4,000 followers on Twitter, the BelAIR app has 9,000 active users.

Data for cities

The UHI, detailed in section 2.1.2 causes heatwaves to be more intense and to last longer (earlier start and later end) in an urban environment compared to a rural area. The meteorological models used by RMI cannot consider detailed local effects, hence the effects of the urban heat island (UHI) are not captured in their forecast nor analysis. In the broadcasted meteo forecast it is sometimes mentioned that temperatures can rise higher in urban areas due to the UHI effect.

For the city of Antwerp, VITO implemented a detailed temperature monitoring-forecasting-warning system, called the Hitteverklikker-service[3]. The system combines information from local temperature sensors with meteorological models, it explicitly accounts for the UHI-effect. The daily forecasts and warnings can be consulted online using a smartphone or pc. The system uses various channels for warning on hot days and in case of heat waves. There is a text messaging service to which you can subscribe to, this is often done by personnel of residential care homes and home care nursing in Antwerp. In case of a heat alert a text-message is sent in the morning.

Heat maps, using apparent temperature metrics such as WBGT and showing the location of cooling zones at high (metre-scale) spatial resolution, are only scarcely available for Belgian cities. Among the best developed maps is that for Brussels (Lauwaet and De Ridder, 2018)[4], of which an example is provided in Figure 5-6. Apart from that, a detailed (but only covering a city quarter) map is available for Antwerp (see Box 2.4 in EEA, 2020) and a coarser (but city-wide) map has been established for Ghent (Lauwaet et al., 2020).

[1] http://www.meteoalarm.eu/

[2] https://www.irceline.be/en/front-page?set_language=en

[3] https://hitteverklikker.antwerpen.be/

[4] https://environnement.brussels/lenvironnement-etat-des-lieux/en-detail/climat/cartographie-des-ilots-de-fraicheur-bruxelles

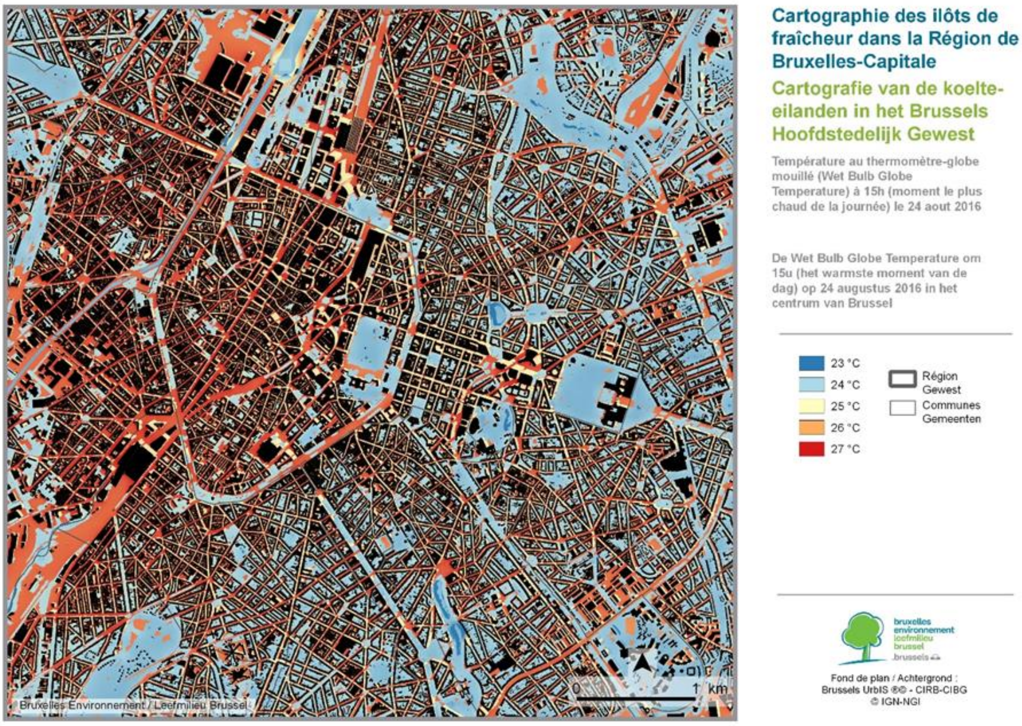

Figure 5-6. Wet bulb globe temperature (WBGT) at 15:00 local time on 24 August 2016 for the centre of Brussels. It should be noted that the WBGT values shown here (roughly between 23°C and 27°C) cannot be interpreted in terms of the commonly used air temperature. Source: Bruxelles environnement / Leefmilieu Brussel (Lauwaet and De Ridder, 2018).

In a project for the Flemish Environmental Agency (VMM) VITO will establish a high-resolution WBGT-map for Flanders, results are expected by the end of 2022. In another project VITO is currently calculating a WBGT-map for the city of Liège.

Coupling heat maps with vulnerability mapping

The information from the heat maps using can be coupled with other data to generate relevant information. Heat-impact maps can be made by the combination of heat maps with vulnerability maps that can be made up at the level of the statistical sector (detailed in section 4.3.2). In this way heat-impact maps can be made at the level of the statistical sector. Figure 5-7 shows an example of a heat-impact map for Flanders and Brussels. This map was created for all Flemish communities on behalf of AZG. These maps have been made available by AZG to local authorities to provide information on the vulnerability of the different statistical sectors within their territory to prioritize prevention and adaptation actions.

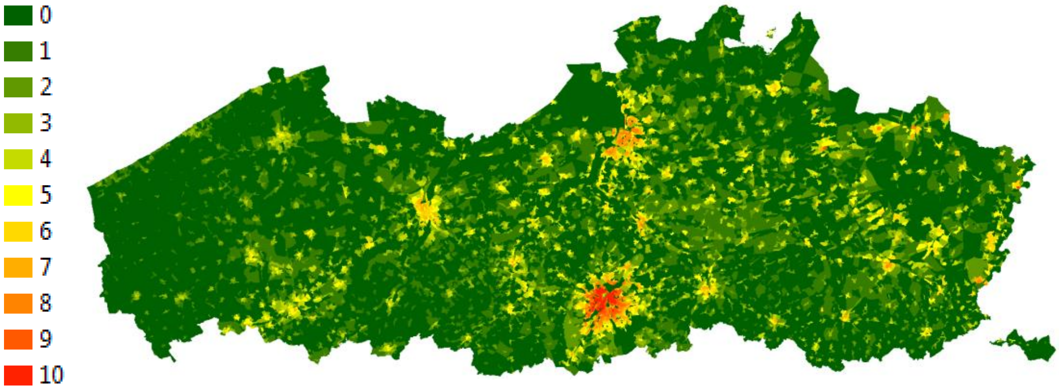

Figure 5-7. Heat impact map for Flanders and Brussels. Source: Hooyberghs (2018).

The identification of current cooling zones in heat maps can be used as input for the development and implementation of spatial planning policies, e.g. in Antwerp this map was used to redesign the area of de Gedempte Zuiderdokken[1].

5.1.3.1.2 Heat-related mortality and morbidity: monitoring and surveillance of current situation, short-term forecast

Sciensano performs annually a surveillance of mortality all causes during the summer for Belgium and the three regions. Results from this surveillance have been discussed in previous sections.

No analysis has been made for Belgium concerning the link between heat and morbidity with hospitalization data, emergency department data, medication data. As discussed in section 5.1.1.3 an analysis of heat-related general practitioner visits in Flanders is ongoing (Alsaiqali, 2021).

5.1.3.1.3 Geographical information on cooling opportunities

Heat maps, using apparent temperature metrics such as WBGT, show the location of cooling zones at high (metre-scale) spatial resolution, see above in section 5.1.3.1.1.

There are several local initiatives that give public access to the location of fountains of potable water, e.g. in Brussels[2] and Antwerp.

Within the aforementioned Hitteverklikker-system cool indoor and outdoor places were identified in the St-Andries neighbourhood in the city of Antwerp. They include a residential elderly home and a community centre, the information on the location of the cool indoor and outdoor places is available on a map[3] (see also section 5.1.3.3).

5.1.3.2 Ozone- and heat plans

Since 2004, Belgium has a federal "Ozone and Heat plan"[4] ('Plan federal forte chaleur et pics d'ozone' in French, 'Federaal ozon- en hitteplan' in Dutch) to mitigate public health problems during periods of very hot weather and high ozone concentrations. The National Environmental Health Action Plan (NEHAP) coordinates the implementation of the plan. This working group brings together both federal and regional administrations and institutions to coordinate mitigation actions. Three main phases (described below) can be distinguished: the vigilance phase, aimed at the monitoring of ozone and heat by respectively IRCEL and KMI/IRM; the warning phase, where the regions take initiatives in informing the population, and the alert phase, where action is taken at the federal level.

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[1] https://www.antwerpenmorgen.be/nl/projecten/gedempte-zuiderdokken/over

[2] https://www.brussel.be/sites/default/files/bxl/4-Plan-IDR-fontaine2019-A2-flyer-print-compresse-769-.pdf

[3] https://hitteverklikker.antwerpen.be/

[4] https://www.health.belgium.be/nl/node/28600

As mentioned above, the regions have their own regional plans during the information phase, and themodalities are respectively described in the "Vlaams Warmteactieplan"[1]; the “Plan d'action Wallon Forte Chaleur"[2] and the “Plan d'action Bruxellois Forte Chaleur"[3]. The regions are responsible for watchfulness and for sending out heat warnings. The alert phase is a federal competence as it is considered a crisis phase. The regional authorities do support communication during this phase.

5.1.3.2.1 Activation criteria

The **vigilance phase** is fixed and runs every year from 15 May until 30th September. Its activation does not depend on criteria relative to temperature or ozone concentrations. The **warning phase** (waarschuwingsfase/phase d'avertissement) is activated at J0 when several warm days are predicted by RMI at the station of Uccle, the criterium uses the predicted daily maximum temperature during 5 consecutive days.

We note that the criteria used for the activation are based on public health risks related to heat, making use of maximum temperature. The criteria are different from the purely meteorological criteria for a heatwave forecast described in section 5.1.3.1.1.

The **alert phase** is declared when measures already taken have to be reinforced due to forecasted heat and (measured and forecasted) ozone peaks. Measurements and forecasts of ozone levels are performed by IRCELINE[4]. In this case, the Risk Assessment Group (RAG) and the Risk Management Group (RMG) meet to decide on additional measures.

The activation criteria for both the warning and alert phases are country-wide. The warning phase of the ozone- and heat plan has been activated in 2015 (1 time), 2016 (3 times), 2017 (1 time), 2018 (2 times), 2019 (3 times) and 2020 (2 times). The alert phase has been activated for the first time in 2020.

5.1.3.2.2 Proactive and reactive measures for general public

Most measures are dealing with the provision of indoor and outdoor cooling, personal health care, social control and information. Measures are to be taken by individuals and/or local organizations as well as authorities. One can distinguish between proactive and reactive measures, proactive measures can be taken all the time, reactive measures during a warning and/or alert phase. Table 5-2 gives for every aspect an example for a proactive as well as reactive measure, to be taken by individuals and authorities. We note that this list is not complete but only intends to give examples of measures that are taken up in the federal and/or regional ozone- and heat plans.

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[1] https://www.warmedagen.be/

[2] http://sante.wallonie.be/?q=plan-wallon-forte-chaleur-pics-ozone

[3] https://leefmilieu.brussels/themas/lucht-klimaat/ozon-en-hitteplan

[4] https://www.irceline.be/nl

Table 5-2. Examples of proactive and reactive measures to be taken by an individual or an organization/authority.

	Proactive		**Reactive**	
Measure	**Individual**	**Organization/ authority**	**Individual**	**Organization/ authority**
Cooling inside	installation of cooling systems	subsidies for installation of energy -efficient cooling systems	correct use of cooling systems	provision of cooling rooms
Cooling outside	provision of shade, blue and green infrastructure in garden	provision of shade, blue and green infrastructure in public domain	look for shade	provision of water sprayers
Personal health	good physical condition, information on medication use	provision of information	personal protection, adapted drinking and eating	Contact chronically ill or elderly people living alone
Information	knowledge of information & warning sources	inform intermediaries, set up information & warning systems	follow-up of information & warnings	provision of information & warnings
Social control	contact details of neighbours, family, friends	setting up neighbourhood networks	contact neighbours, family & friends	contact socially isolated people

The working group "Ozon and Heat" of NEHAP has started in 2020 with the identification on extra health measures that can be taken to promote adaptation to heat waves as well as in emergency situations. Potential actions applicable in respectively short and long term have been identified in different sectors. Examples of potential measures applicable in short-term during the alert phase are water distribution by public instances as well as the catering sector, opening of air-conditioned public buildings, restriction on sale of alcohol, traffic bans, etc. Actions applicable in a long-term are setting requirements for green & blue spaces in urban development, subsidies for green roofs and heat isolation, etc. The feasibility of these measures is currently under study.

5.1.3.2.3 Advice and vulnerable groups

The federal and regional heat- and ozone plans focus in their advices on the prevention of health effects due to heat- and/or ozone-related exposure for the general population. They give general advice on cooling (inside and outside), personal health, information and social control. For a number of heat-related pathologies an overview is given of the symptoms and their treatment. Not all plans are equally detailed, e.g. the Brussels plan is rather concise. The plans also target vulnerable groups with specific advice. Table 5-3 gives an overview of the vulnerable groups (see section 4.3.1) for heat-related health effects, and the indication if they are specifically addressed in the different heat-health action plans (or the related health advice plans). The extent to which advice is given per vulnerable group is varying. Data for the federal plan are taken from the results of a JICEH (FPS-Health, 2005).

Table 5-3. Overview of groups vulnerable to heat-related health effects and indication if they are addressed in different heat-health action plans.

Factor	Vulnerable people	Federal	Brussels	Flanders	Wallonia
Age	Elderly	x	x	x	x
	Babies and young children	x	x	x	x
Environmental	Urban regions			x	
Medical	Chronically ill	x	x	x	x
	Hospitalized or patient			x	x
	Limited mobility	x		x	x
	Mentally ill	x		x	
	Pre-existing disease	x	x	x	x
	Obese			x	
	Use of medication	x	x	x	x
	Substance abuse	x			
	Pregnancy				
Social	Socially isolated	x	x	x	x
	Homelessness				x
	Socio-economic status	x		x	x
	Physically active	x	x	x	x
	Tourist				
	(Outdoor) workers	x			x
	(Religious) fasts				

5.1.3.2.4 Advice for healthcare sector and other sectors

The Flemish and Walloon plans provide on their websites specific guidance for health professionals, personnel of childcare and residential care for elderly, home care personnel, caretakers (separate guidance for working/caring for elderly, socially isolated people), sportsmen as well as for organizations (e.g. sports events, cultural events).

5.1.3.2.5 Implementation of heat-health plans in healthcare facilities

The online survey among health care institutions indicates that (almost) all hospitals (general and university) as well as elderly care residences have a heat plan in place, see Table 5-4. This heat plan structures additional (care) activities for health care personnel during a period of increased heat.

Since heat waves and increases in temperature have been indicated as a high concern as well as a high priority for health care institutions, it is not unexpected that preparation in terms of heat plans reaches high adoption levels in the sector. Several interviewees mentioned that some mechanical elements of cooling are automated, but these levels of automation in elderly care residences differ based on their age and maturity level. In centres or hospitals with psychiatric and/or disabled patients, activities are also adapted in a similar way as in the elderly care facilities. However, from both the survey results as well as interviews, it is less clear to what extent these activities are structured and written into a heat plan or a specific protocol (Anonymous, 2021a).

Table 5-4. Online survey results for the question 'Does your institution have a plan or protocol which is active during a heat wave?'

	Yes	No, ad hoc adaptation of activities while working on a heat plan	No, ad hoc adaptation of activities and increased vigilance	No adaptation
General hospital	95%	0%	5%	0%
University hospital	100%	0%	0%	0%
Psychiatric hospital	90%	0%	10%	0%
Institution for persons with disabilities	61%	9%	26%	4%
Elderly care home	100%	0%	0%	0%
Rehabilitation hospital	75%	0%	25%	0%

5.1.3.2.6 Local implementation of heat-health plans

The measures that are needed to make a geographic area (e.g. city, village, neighbourhood, …) or a certain sector or setting (e.g. schools, elderly homes, …) climate/heat proof, depend on the local circumstances. This includes aspects such as type of housing (apartments vs houses), availability of green infrastructure (private gardens vs public parks) demographic information (e.g. age, socio-economic status), …. Hence climate adaptation must be tailored to the local needs and must be implemented at the local level.

The majority of Belgian cities and municipalities disposes of an energy and climate plan as detailed in section 4.2.4, this plan often contains a section dedicated to heat. Adaptation measures range from reactive short-term initiatives at a small scale (e.g. water distribution) to proactive actions at a medium-term (e.g. promoting the installation of sunblinds for houses) to a large scale and long-term (e.g. spatial planning measures) (see also Table 5-2). From a consultation of a series of local plans it becomes clear that the actions often remain in the domain of energy efficiency of buildings, spatial planning, urban design or environmental departments. As shown below these actions are important to take, but there is a need for further involvement of public health and social care professionals in local adaptation planning and implementation to reduce the human health impacts, including impacts on vulnerable groups. The focus for climate change adaptation in the environmental domains not only applies to the Belgian context, but was also observed in a European study (EEA and Lancet, 2021). The same applies for the toolkits provided by the regional authorities and detailed in section 4.2.4.

The federal and regional heat and ozone action plans provide general guidelines for preventive actions and measures that can be implemented at the local level. Local authorities can be assisted by the local health promotion centres that help realizing the health promotion and prevention policy at local level (see also section 3.3). However the role and responsibilities of local actors is not clearly defined, this results in a large variation in the number of activities between different municipalities (Van Loenhout et al., 2016). Furthermore, the definition and implementation of a local heat action plan is not legally required.

However, one needs to be cautious with the conclusion that if the climate plan does not mention specific heat-related actions nor the involvement of local social and health care is described, that no measures are being taken. Very often the preventive activities of these instances ares included in other local programs (Logo's, personal communication May 2021). In several cities and communities initiatives run in parallel to the heat- and ozone plans, and community centres ('Lokale Dienstencentra' in Dutch, 'Maisons de Quartier' in French) provide actions. In Brussels the Local Centre for Public Welfare provides for socially isolated or vulnerable people the possibility to register through a phone call to ensure protection in the event of a severe heatwave (e.g. regular contact, distribution of water, inspection of the living conditions, etc.)[1].

5.1.3.2.7 Communication strategies

IRCELINE informs the competent authorities to announce the start and end of the warning and alert phases of the ozone-heat plan. When the warning phase of the ozone-heat plan is activated, the regional and local action plans come into action. AZG, AVIQ and COCOM send out information letters to local authorities, services and residential care for elderly, health sector (psychiatric) hospitals, mental health services, organizations working with sensitive groups, etc. The mailing list of AZG counts 10,500 recipients, for AVIQ this amounts to 2,000-2,500 recipients. The regional and local authorities communicate with the population, give tips on measures to be taken. In this phase the FPS-Health has a coordinating role through NEHAP. During the alarm phase the FPS- Health coordinates the execution of measures. A free telephone number is activated for information for general public. In the media the activation of the warning and alarm phases is widely covered, urging people to take measures.

The federal and regional ozone- and heat plans are available online in the language of the region as is required in the official communication from the government. The Brussels plan doesn't mention other communication strategies on their website. The Walloon plan provides the possibility to download flyers and folders. The Flemish plan provides a lot of supporting downloadable materials, including sector-specific and target group-specific guidance as well as inspiration documents. All materials use icons and keep texts to a minimal, they use simple language. AZG also provides practical ready-to-use information that can be printed out and provided to vulnerable people, see left and middle panels of Figure 5-8.

Figure 5-8. Ready-to-use information for vulnerable people. Sources: website AZG [2] and Hitteverklikker.

[1] https://www.brussel.be/hittegolfplan-helpt-brusselaars-tijdens-zomer

[2] https://www.warmedagen.be/gratis-campagnemateriaal

The aforementioned Hitteverklikker-system (detailed in section 5.1.3.1.1) provides an option to print actual and forecasted weather information together with health advice. A caregiver can print out a simple overview of temperature, accompanying tips and the indication of cool places in the neighbourhood, see right panel of Figure 5-8. This paper can be put in a visible place in the elderly person's home.

Educational activities on climate change and associated health risks are important for children and youth. Educational kits have been developed for different age groups and are available online[1].

5.1.3.2.8 Evaluation

The NEHAP working group on ozone and heat meets twice a year as a rule, and more often if deemed necessary. One meeting is organized before the activation of the vigilance phase in Spring to prepare for potential heatwaves, fine-tune the protocols, and update the information bulletins and contact lists. The second annual meeting is held in Autumn, where RMI presents a meteorological review of the summer compared to long-term averages, IRCELINE presents the air quality overview of the summer period, and Sciensano presents the excess mortality recorded during the summer period, as also reported in the weekly Be-MOMO bulletins. The second part of this meeting is dedicated to the evaluation of the activation of the different phases, its impact on prevented mortality, and the feasibility of the proposed interventions with all partners present, both federal and regional. Recommendations are formulated and implemented by the Spring meeting of the following year.

5.1.3.3 Indoor thermal climate

In this section we focus on the thermal climate aspect of indoor environment, other aspects are discussed in section 7.1.

Heat risks associated with the indoor environment are affected by a combination of different factors. First of all the location of the building and hence the outdoor environment has a great influence on the quality of the indoor environment. The location determines the variation in indoor temperatures, in the warm season indoor and outdoor temperatures are correlated. However the variation in indoor temperature between homes is considerable (Franck et al., 2013). Furthermore outdoor temperatures explained only a small proportion of the variance of indoor temperature, indicating there are other factors (Smargiassi et al., 2008). Building characteristics (e.g. building materials, age of the building, presence of thermal insulation, roof type, colour of walls and roof, ventilation and aeration possibilities etc.) are important parameters that affect the indoor environment. The indoor environment is also influenced by occupant's behaviour and emission sources used inside. This is especially the case in hospital and residential care buildings where heat is generated by the presence of a lot of people (inhabitants and personnel), many electronic devices, …

People living in a temperate climate such as in Belgium, and especially elderly, typically spend about 90% of their time indoors. Exposure to indoor temperatures and pollutant levels is hence a more exact predictor of heat exposure than outdoor parameters. This observation was confirmed in a study by van Loenhout et al. (2016) carried out with elderly residents in the Netherlands. They found that living room and bedroom temperatures were positively associated with substantial increases in reported heat annoyance, thirst, sleep disturbance and excessive sweating.

Population groups vulnerable to heat have a different sensitivity to heat and thermal comfort, this has not been studied well. A systematic review found a difference in temperature of thermal comfort between younger adults and older people in a range from 0.2 °C to 4 °C (WHO Regional Office for Europe, 2021).

[1] https://klimaat.be/in-belgie/communicatie-en-educatie/educatief-aanbod

5.1.3.3.1 Building standards, regulation and implementation

The EU has established a legislative framework in order to boost energy performance of buildings, this includes the Energy Performance of Buildings Directive 2010/31/EU (EPBD) and the Energy Efficiency Directive 2012/27/EU[1]. The implementation of the minimum requirements of the EPBD is a regional responsibility in Belgium. Energy Performance Regulation (EPB) is the instrument to realize a high energy efficiency and healthy indoor climate. There is an obligation to keep the total energy consumption (and hence CO_2 emissions) below a maximum, but the regulations are largely technology-neutral as there are no requirements on the technology being used. The EPB-requirements depend on the nature of the works (new buildings, retrofitting, major energy renovation, …) and exist in different areas: thermal insulation, ventilation, technical installations, etc. Indicators exist for expressing energy performance, they are different for each region.

The National Energy and Climate Plan 2021-2030 (NECP), together with the federal and regional climate-energy plans take measures in order to comply with the aforementioned European guidelines. Measures include accelerating renewal rates for old fossil fuel boilers in combination with their progressive phase-out, green heat from different heating technologies, improving the energy performance of new buildings through a revised energy performance certificate, introducing renovation contracts at district level. Both the federal and the regional authorities take legislative measures, fiscal measures (e.g. lowering registration taxes) and financial incentives (e.g. providing cheap loans) in order to increase the energy efficiency of the building sector. Measures are taken both for residential buildings as well as non-residential buildings, the healthcare sector belongs to the latter. The plans also mention actions related to the organization of education and awareness campaigns in order to inform citizens about energy efficient behavior at home in order to reduce energy consumption. Below we give some details of the federal and regional plans as well as the competent authorities.

The Flemish Climate Policy Plan 2021-2030 describes for the building sector the policy objectives and measures including e.g. energy-neutral building, renovation, sensibilization and information, financial stimuli, energy regulation, and a climate-sustainability action plan for healthcare sector[2]. The involved authority is the Flemish Energy- and Climate Agency (VEKA)[3] that prepares, stimulates, implements and evaluates energy-efficient measures a.o. for the building sector, it also provides subsidies.

The Walloon Plan Air Climat Energie à l'horizon 2030 (PACE2030) of the Walloon region foresees actions to improve the energy efficiency of buildings with technical improvements regarding insulation, heating and ventilation systems. The Walloon contribution to the NECP, Plan Wallon Energie Climat foresees the implementation of measures linking to energy-efficiency (concerning heating, cooling, ventilation and lighting) in the building sector, both for residential and non-residential buildings. This includes legislative and fiscal measures, granting, but also information and awareness rising. The renovation strategy is further detailed in a document set up by SPW Energy[4]. The involved authority is the SPW Energy[5] that prepares, stimulates, implements and evaluates energy-efficient measures a.o. for the building sector, it also provides subsidies.

The Energy-Climate Plan 2030 of Brussels foresees the implementation of measures linking to energy-efficiency in the building sector, both for residential and non-residential buildings. They provide technical, administrative and financial support for households. The involved authority is Brussels Environnement[6].

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[1] https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en

[2] https://www.departementwvg.be/vipa-duurzaam-bouwen-zorg-voor-klimaat-wvg-zet-zich-13-engagementen

[3] https://energiesparen.be/

[4] https://energie.wallonie.be/servlet/Repository/strategie-wallonne-a-long-terme-pour-la-renovation-energetique-des-batiment.pdf?ID=47301

[5] https://energie.wallonie.be/servlet/Repository/strategie-wallonne-a-long-terme-pour-la-renovation-energetique-des-batiment.pdf?ID=47301

[6] https://www.guidebatimentdurable.brussels/fr/accueil.html?IDC=1506

Concerning the building sector, the Federal Energy and Climate Plan 2021-2030 (FECP) supports the regions by pursuing policies in the areas of taxation, renewable energy, energy-efficient federal public buildings etc.

5.1.3.3.2 Cooling techniques

As mentioned above, building regulations for newly built or retrofitted residential and non-residential buildings, tend to focus on climate-mitigation measures (CO_2 reduction) by reducing energy consumption for heating (and cooling). This is preferably done using passive techniques (WHO Regional Office for Europe, 2021). Below we discuss some commonly-used techniques.

Thermal insulation

Thermal insulation of walls, floors, roofs is an important energy-saving investment for heating in a moderate climate such as Belgium. However in a UK study it was found that newly constructed houses with high levels of insulation generally have the potential to be at higher risk of overheating than older, less well insulated houses (Vardoulakis et al., 2015). Hence if isolation measures are taken in the infrastructure of new-built or retrofitted buildings, adaptation of the ventilation policy is necessary in order to overcome this problem. This aspect was also pointed out in the recent report "Heat and health in the WHO European Region: updated evidence for effective prevention" by WHO Regional Office for Europe (2021), building regulation changes for energy efficiency should require retrofitting in combination with shading or passive cooling strategies.

Passive cooling

Passive cooling interventions are preferable as they minimize energy consumption and can be applied both in new constructions and retrofitting.

Shading solar radiation can be implemented preferentially externally through overhangs, shades or shutters. If this is not possible shading can be applied internally through blinds or curtains, however this is less effective as the heat can enter the building in this way. Hooyberghs et al. (2017) conducted simulations of indoor thermal comfort for a typical office building in Antwerp using urban climate simulations together with detailed building energy balance calculations, accounting for building characteristics such as thermal inertia, wall isolation, exposure of windows with respect to solar position throughout the day, and the dimensioning of the ventilation system, among other. The use of solar blinds reduced the total energy demand for cooling by 28 % for an average summer (May-September) and decreased the number of lost working hours (due to high indoor temperatures) for desk workers (Hooyberghs et al., 2017). It is of importance to correctly operate solar shading devices. Sun-blocking screens should be lowered before the sun shines directly on the window in order to keep the incoming solar radiation at a minimum. This has a drawback that the quality of natural day light is decreased. Under extreme temperatures, solar shadings offer limited protective effects, however the recent WHO-report suggests installing solar shutters in dwellings inhabited by the most heat-vulnerable populations as a realistic option (WHO Regional Office for Europe, 2021).

Thermal mass may help reduce the risk of extreme temperatures. Heavy construction materials for floors and/or walls, such as concrete and stone, generally increase the thermal mass of a building, meaning that internal air temperature responds slowly to external variations. Thermal mass can hence reduce the peak indoor temperature during the day, but also keep the building warmer during the night. Therefore, effective temperature control is required through night-time cooling in buildings constructed with these materials.

Geothermal cooling takes advantage of subterranean temperatures to provide cooling in the summer, this can be achieved by top-cooling using a ground source heat pump, or by a borehole thermal energy storage system.

Night-time cooling refers to natural ventilation at night in order to purge excess heat. It is important to assure that the outside temperature is lower than the inside temperature when conducting night-time cooling. A building with sufficient thermal mass, which can be exposed to nighttime ventilation, can reduce peak daytime temperatures by 2-3 °C using this strategy (Vardoulakis et al., 2015). In case night-time cooling is performed through opening doors and/or windows, this technique is limited by security issues. More information on ventilation techniques is available in section 7.1.3.

Green techniques (further discussed in 5.1.3.4) such as green roofs and walls can provide extra protection for indoor heat. A complete review of various technologies by Buchin et al. (2016) assessed the indoor heat reduction potential of non-irrigated green roofs and facades as low. Irrigation makes a great difference in the heat mitigation performance of the green roofs by increasing evapotranspiration.

Active cooling

A wide range of active cooling systems are available on the market including fans, air-conditioning (AC), humidifiers, …

In several countries **air-conditioning** is becoming the most used technology for protection from overheating. In Belgium 3,1% of the population uses air conditioning, this share is considerably lower than the EU average of 10.8 % (data from 2007, Eurostat 2012). Air-conditioning has several drawbacks: increased energy use, emission of waste heat that contributes to the urban heat island effect and the emission of greenhouse gases. Most AC systems have no air inlet from outside but instead recirculate the air, this can give rise to deteriorating indoor air quality when there is no ventilation or air purification system. There is a risk of inequitable access for vulnerable groups as they cannot afford the costs of AC. When spending most of the time in AC environments, the dependency on it can increase, leading to loss of resilience. Hence WHO Regional Office for Europe (2021) states that AC is a clear example of potential maladaptation, an action that could result in increased vulnerability or risk from climate change. But on the other hand, in addition to a range of effective passive cooling interventions, the use of AC has health-preventive benefits.

The development of **sustainable** active cooling technologies needs to be promoted, the combination of ventilation systems with heat exchangers can also decrease the cooling demand.

5.1.3.3.3 Cooling rooms or centres

Air-conditioned spaces that are publicly accessible, can offer a cool break for vulnerable groups. In different cities there are projects with cool rooms in libraries, community centres, etc. Within the aforementioned Hitteverklikker-system[1] cool indoor and outdoor places were identified in the St-Andries neighbourhood in Antwerp, amongst which a residential elderly home and a community centre. It turned out that people indeed went to the community centre, however the elderly home was not used by outsiders.

The transportation time from home to a cooled space can be another barrier to the use of them. For some people maximum walking distances without a rest or without aid are limited to around 100 m (WHO Regional Office for Europe, 2021).

The infrastructure conditions for residential care for elderly, state various conditions and measures for guaranteeing an optimal temperature in accommodation areas. An air-conditioned cooling room must be available and of sufficient size in order to accommodate all residents whose living quarters do not reach the required temperatures in the event of a heat wave. More information is available from AZG[2]

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[1] https://hitteverklikker.antwerpen.be/

[2] https://www.zorg-en-gezondheid.be/sites/default/files/atoms/files/16-17044%20BVR%20wijz%20bijlage%20XII%20infrastructuurvoorwaarden.pdf

and AVIQ[1].

5.1.3.4 Spatial planning: green-blue infrastructures

5.1.3.4.1 Green-blue infrastructures and heat-health

Green and blue spaces deliver a triple win, offering benefits for health, society and the environment. We focus here on the benefits to mitigate and adapt to increasing temperatures. The other health benefits are covered in sections 5.5 and 7.2.

Green measures are an efficient way of tackling heat stress primarily by providing shade, since radiation is an important factor for thermal comfort. They also reduce air temperatures through the cooling process of evaporation and evapotranspiration. The magnitude of the cooling in question is dependent on the type, size, health and density of the given vegetation. The canopy cover of trees is closely linked to resulting cool, with deciduous trees providing better cooling effects than coniferous trees (Meier and Scherer, 2012). In the EEA-report "Healthy environment, healthy lives: how the environment influences health and well-being in Europe"' an overview of the evidence of cooling by vegetation is given (EEA, 2020c). They stress that local cooling through vegetation may only be possible through high levels of irrigation in warm, dry climates, this was also stressed in (WHO Regional Office for Europe, 2021). Substituting greenery for typical urban surfaces and materials contributes to decreasing the urban heat island effect. Even though the complexity of the relationships involved made determining a causal relationship difficult, evidence is increasing that availability and accessibility of green spaces can reduce the risk of heat-related cardiovascular and all-cause mortality in the vicinity of such spaces (Gascon et al., 2016).

In addition to the health-protecting effect of green spaces, an increasing number of studies are focusing on the ecosystem services of blue infrastructure such as pools and ponds. For the water elements it is important that water can evaporate easily, then the cooling effect will be largest, e.g. in the case of a spraying fountain or a water spraying play area. Shallow, stagnant water surfaces are not recommended as they release their stored heat at night and can thus increase the urban heat island (Lauwaet et al. 2020). Also the water-borne diseases (see section 5.3.1.1) and transmission of vector-borne diseases through mosquitoes (see section 5.2.4.4) should be considered when installing e.g. wadis.

5.1.3.4.2 Implementation of green-blue infrastructures

Measures that are being discussed within the NEHAP working group "Ozone & Heat" ("Ozon en Hitte" or "Forte Chaleur et Pics d'Ozone"), e.g. to encourage municipalities to have a "greening plan" to limit the effect of the heat: plant trees in the street, put green facades on public buildings, etc. or attractive incentives to protect homes from the heat: installation of sunshades, green facades, green roofs, roof insulation, etc. will help to reduce the effect of heat.

One of the five strategies of the **Flemish Adaptation Plan 2021-2030** is the optimization of green and blue networks. At the local level green and blue networks have to be included in the spatial development of village centres and urban districts. The urban green space includes parks, but also private gardens and green walls and roofs of both public and private buildings. The coordination of urban developments should take the water system into account with e.g. the restoration and development of water structures. The plan also mentions the importance of large green spaces such as urban forests, which act as cool oases for the population and as a source of cool air to mitigate the heat island effect. The Flemish government is working with local authorities and local stakeholders on a so-called climate buffer program. This program offers the inhabitants of urbanized areas the easily accessible, cool and shady areas they need, areas that are adapted to the specific wishes and needs of the social groups involved (e.g. the elderly, children, ethnic-cultural groups). This program is

[1] http://sante.wallonie.be/sites/default/files/aines_reglementation.pdf

coordinated by the Coordination Commission Integrated Water Policy[1]. After approval of the Flemish adaptation plan, the different strategies will be materialized in a multi-annual action plan. The strategy coordinator of the green and blue networks strategy is INBO and Flemish Department Environment.

The Flemish Department of Environment is currently investigating how green and blue spaces can serve as building blocks for resilient healthy living environments. The aim is to provide a guide for local authorities on how to design green and blue spaces as healthy as possible, taking into account both positive and negative health effects. Study results are expected end of 2021.

The Plan Wallon Energie Climat foresees green infrastructure for the urban environment, to contribute to the fight against the urban heat island and to better manage rainwater, such as: the greening of roofs, the planting of trees and/or the permeabilization of soils (especially parking areas, etc.). A concrete target is that in all urban development projects of more than 2 ha it is obliged to create private green spaces for a minimum of 10% of the surface area.

The "Plan wallon Environnement-santé 2019-2023" (ENVIeS) foresees an action in order to quantify ecosystem services provided by urban gardens (SPW Environnement-santé, 2019). The objective is to develop and validate an integrated methodology for evaluating the services provided by green spaces for use by decision-makers and land managers. In addition to the analysis of existing evaluation methodologies in the literature, measurements will be carried out in the field and in the laboratory on the functioning of soils for different case studies, surveys will be conducted among the different publics and social and health actors and the results will be integrated into a methodological vademecum for decision-makers. The responsible authority for carrying out the action is SPW-DG03-DEMNA.

The Brussels Regional Plan for Sustainable Development (GDPO/PRDD)[2] foresees general principles for urban design including green and blue spaces. The Brussels Regional Air-Climate-Energy Plan foresees the installation of a green network for the entire Brussels territory, in cooperation with local communities. Concerning the development of green roofs, the plan continues the current financial support measures[3] and will develop a new policy concerning the obligation of greening roofs (to realistic minimum surface area thresholds) in case of renovation.

In several climate-energy plans of provincial and local authorities the creation of green and blue cooling zones is mentioned explicitly. There is a general focus that recreational green and blue spaces should be easily accessible. E.g. the Antwerp Adaptation Plan 2021-2030[4] ensures the availability of green or blue cooling zones with a resting bank, within 150 m of every building.

5.1.3.5 Large events

Organizers of large sports or cultural events are legally obliged to draw up a safety plan, this includes preventive measures in case of extreme weather conditions. AZG provides in their ozone and heat plan guidelines[5] in order to define measures concerning both the lay-out of the event area as well as the behavior of the participants/visitors. No guidance is available in the Walloon and Brussels ozone- and heat plans.

The Belgian Red Cross offers first aid at events such as music festivals and sports matches. The Red Cross works mainly with first aid volunteers, they can provide first aid but are not allowed to carry out medical procedures. The Flemish Red Cross' Centre for Evidence-based Practice estimated that for every degree rise in temperature nearly 100 more people are cared for per festival day[6]. In the past organizers of sports events and music festivals already took measures such as free water distribution, this is however not compulsory.

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[1] https://www.integraalwaterbeleid.be/

[2] https://perspective.brussels/fr/plans-reglements-et-guides/plans-strategiques/plan-regional-de-developpement-prd/prdd

[3] https://www.brussels.be/bonus-green-roof?_ga=2.172227050.831519892.1623827601-325626869.1623827601

[4] https://www.antwerpenmorgen.be/nl/projecten/klimaatplan-2030/media

[5] https://warmedagen.be/sites/default/files/atoms/files/Finaal_mei_2018_leidraad_Warme_Dagen_evenementen_0.pdf

[6] https://www.rodekruis.be/nieuws-kalender/nieuws/klimaatopwarming-heeft-gevolgen-voor-onze-werking-/

For some heat-related health effects, such as heat stroke, it is important to provide cooling as soon as possible. When cooling is delayed, there is a significant increase in organ damage, morbidity and mortality (Belval et al., 2018). In the Netherlands the Red Cross therefore promotes the introduction of cooling baths, a medical procedure that can be used to treat patients with heat stroke[1]. As this is a medical intervention, supervision by a medical doctor is needed, first aid volunteers can only provide support in the use of cooling baths.

5.1.4 Gaps between risks and current/planned measures - Adaptation actions and recommendations

5.1.4.1 Data availability

5.1.4.1.1 Heat and heatwaves

As mentioned in section 5.1.2 we use in this report climate data calculated by RMI within the CORDEX.be project. However, by the end of 2021 the 6th IPCC Assessment Report will be published, the underlying climate data (CMIP6) are already (partly) available. It would be of interest to set up new projections for Belgium on the basis of CMIP6-data.

As mentioned in section 5.1.3.1.1 the UHI gives rise to more intense and longer heatwaves in urban areas. Some, mainly larger, Belgian cities already dispose of WBGT-maps indicating cooling zones and have detailed temperature forecast and warning systems. As heat waves' frequency, intensity is expected to increase and also affect smaller cities, this type of information will become indispensable for the local development and implementation of urban adaptation plans, not only in large cities but also in the smaller ones. It would be of interest to develop an area-wide high-resolution WBGT map for Belgium for the current situation as well as for 2050 and beyond. In this way local authorities can dispose of and make use of data that are generated using a harmonized approach.

5.1.4.1.2 Heat-related morbidity

In Belgium no analysis has been made for heat-related hospitalization, however this is possible using the anonymized registration system for administrative, medical and nursing data (RHM-data).

No data is publicly available for emergency department admissions, while this information is being registered (see section 3.6).

Intego (section 3.6) is planning to analyze the Flemish general practitioners' data in relationship with heat parameters.

5.1.4.1.3 **Heat-related mortality: research on excess mortality**

The assessment of the excess mortality during heatwave episodes shows that not in all years with heatwaves, the excess mortality is of the same extent. This can be due to the harvesting effect with possible excess mortality in the winter period before due to stressors such as cold, air pollution, flue (mentioned in section 5.1.2.3), but also the characteristics of the heatwave (length, temperatures, ozone concentrations, …). Increasing heat may not increase health impacts due to the implementation of Heat Health Action Plans, increased awareness and self-protection, improved quality of life, improved housing standards, increased use of air conditioning and better healthcare (WHO Regional Office for Europe, 2021). In many European countries the impact of heat on cardiovascular mortality is much higher than on hospital admissions due to cardiovascular diseases, in Flemish elderly care homes this discrepancy has also been observed (see section 5.1.). It would be of interest to further enquire this. Excess mortality in Belgium is analyzed per season with Be-MOMO (winter 2018-19 is

[1] https://www.rodekruis.nl/nieuwsbericht/ehbo-is-geen-medische-hulp-zembla-over-evenementenhulp-en-het-rode-kruis/

almost published).

5.1.4.1.4 Health impact assessment

A quantitative assessment of the burden of disease for heat-related exposure can provide valuable information for policy makers. This also allows to put data into perspective and compare with other environmental burden of disease estimates. In order to conduct a quantitative health impact assessment, the above-mentioned morbidity and mortality data are necessary.

5.1.4.1.5 Geographical information on cooling opportunities

As shown in section 5.1.3.1.3 in Belgium there are several local initiatives that give public access to climate-related geographical data such as heat-stress maps, position of drinking water fountains. However, there is no central website/app where this information is available for **the whole of Belgium**. In the Netherlands there is a website with the location of drinking water fountains for the entire country[1]. It is possible that the uniform presentation of the data increases the use of it, certainly in the case of water fountains as you might know the locations in your familiar neighbourhood but not in places you pass by on a trip.

. As mentioned in section 5.1.3.3 it is of importance that cool places are within a small distance from home. For several Dutch cities a map exists with the "**walking time to a cool space**"[2], this not only indicates the position of the cool places (they have walking time of 0 mins), but also how much time it takes you (at a certain walking pace) to get to a cool space in the neighbourhood. It hence gives the user a further perspective than just the position.

The information of heat maps can be further used to derive information that can be linked to a course of action More applications are possible, such as the mapping of **walking or cycling routes** between two points looking for routes in the shade, with resting points in the shade, water fountains or water parties along the route, etc. These possibilities have been explored in the H2020 Climate-fit.city project[3].

5.1.4.2 Ozone- and heat plans

5.1.4.2.1 Activation criteria

The activation and de-activation phases of the heat plan are nation-wide and are based on measured and forecasted maximum air temperatures as well as ozone levels for the alert phase. Minimum night temperatures are not considered. As mentioned in section 2.1.2 the UHI in cities gives rise to higher daytime temperatures but in particular night temperatures can be higher by 8-9 °C during heat waves. Since sleep quality is disturbed by heat waves (see section 5.1.1.6) and as this further impacts health conditions, it might be useful to take minimum temperatures into account in the activation criteria, especially for urban environments. During the interviews it was mentioned that especially for urban areas the activation of the alert phase sometimes comes too late and the de-activation too early (Anonymous, 2021a).

In other European countries other parameters are being monitored and used for triggering heat warning systems. Within the SCORCH-project an overview has been compiled of parameters often used: morbidity data, mortality data, medical activity and other meteorological parameters but temperature (Vanderplanken, 2021). In the French "Plan National Canicule 2017" an analysis of mortality data showed that in urban environments both the minimum and maximum temperatures affect health, hence they are both used in the activation criteria (Government France, 2017). The trigger levels are determined per department, hence the different alert levels can be activated differently in different departments. An analysis of health indicators of healthcare use and mortality

[1] https://drinkwaterkaart.nl/waar-kan-ik-gratis-water-tappen/

[2]https://www.tauw.nl/actueel/nieuws/handelingsperspectief-hittestress-op-zoek-naar-koele-plekken-in-de-stad.html

[3] https://climate-fit.city/

contributes to the size of the prevention measures taken.

In the Netherlands maximum temperatures are used as activation criterium (RIVM, 2014). All provinces use the same trigger levels, but local forecasts are used and hence the alert levels can be activated differently in different provinces.

The German Heat Action Plan issues heat-health warnings when high levels of heat (using as a metric perceived temperature) and when adequate night-time cooling in dwellings can no longer be guaranteed (UBA, 2017). The plan can be activated at the level of "Länder". During the warning and alert phases health data (emergency departments and hospital admissions, rescue services, on-call doctor services, emergency hotlines and mortality data) are evaluated real-time in order to evaluate the measures taken and to better inform the public.

In the UK the levels of the heat-health watch system are based on threshold day and night-time temperatures, these vary from region to region (PHE, 2015). While the heat-health watch is in operation, real-time data from different health surveillance systems (e.g. GP consultations, emergency department attendances, mortality data) are monitored on a daily basis and a weekly report is published.

5.1.4.2.2 Advice and vulnerable groups

The heat- and ozone plans focus in their advices on the prevention of health effects due to heat- and/or ozone-related exposure. Most advices are short-term reactive measures and can be applied without many preparations, e.g. the advices concerning cooling. Building-cooling related measures are medium-term proactive measures, it would be useful to give the more structural advices in autumn such that people can make preparations. Long-term proactive measures related to buildings (e.g. development of heat protection requirements for building, technical construction measures, etc.) and urban and building planning (e.g. green spaces, reduction of soil sealing in open and public squares) measures are not considered in the plans. As detailed in sections 5.1.3.3 and 5.1.3.4 these medium- and long-term measures related to indoor thermal climate and spatial planning are considered in other policies.

Although the plans are not intended to formulate preventive measures against UV exposure, it may be interesting to mention possible health effects (e.g. development of skin cancer) as the preventive measures against heat and UV radiation are very similar. One can also refer to relevant organizations such as Stichting tegen Kanker / Fondation contre le Cancer[1], this is included in the Flemish plan. For Wallonia SPW Environnement-Santé has a dedicated website to the health effects of UV radiation[2], this is not referred to in the Walloon plan. The German, Irish and UK heat-health plans do mention explicitly the risk of higher UV exposure when spending time outdoors (Irish Government, 2018; PHE, 2015; UBA, 2017). The UK plan also addresses the heat-related problems of air and water quality, water shortage and wildfires (PHE, 2015).

As can be seen from Table 5-3 not all vulnerable groups are covered in the different plans. As illustrated in section 5.1.1.5, pregnant women are a risk group, but they are not addressed in the heat plans. People involved in religious fasts are covered neither, they are addressed in the UK heat-health plan (PHE, 2015) and by the Dutch GGD[3].

Some basic preventive principles mentioned in the federal and regional plans are very general and not tailored to vulnerable groups. We take the advice "Drink more than usually, at least 1,5 litres at rest" as an example. Especially for vulnerable people it is difficult to estimate what 1,5 l is and to keep track on how much they drink. The advice for elderly people "to drink sufficiently and regularly, even if the person is not thirsty" might in some conditions lead to overhydration as several medical conditions can cause the body to retain water (WHO Regional Office for Europe, 2011). A better option in these cases

[1] https://www.cancer.be/

[2] http://environnement.sante.wallonie.be/home/slide/les-rayonnements-ultraviolets--des-amis-tres-douteux.html

[3] https://ggdleefomgeving.nl/omgeving/hitte/hitte-en-gezondheid/

is to change the medication scheme (if possible) or to provide cooling of the body. This effect is mentioned in the Walloon guidance for residential care for elderly, but is not listed among their general recommendations.

More attention should be given in some plans to the effects of heat on medication use, especially for elderly, chronic patients, psychiatric patients. The Flemish guidance for health care professionals has an elaborate overview of different pathologies and medication that give a higher risk, this list is based on the guidance by WHO Regional Office for Europe (2011) .

As shown in section 5.1.1.9 labour productivity levels decrease with increasing heat, both for outdoor sectors but also for the (indoor) service sector. Hooyberghs et al. (2017) investigated different options to reduce the number of lost working hours in an office, amongst which the cooling techniques mentioned in section 5.1.3.3. The largest beneficial effects are observed for an adapted working schedule with a morning (7-11h) and a later-afternoon (17:20h) working shift (Hooyberghs et al., 2017). The web portal R!SICO-iNFO.be addresses heat risks for outdoor workers[1], the other plans do not. In the French heat plan recommendations are available both for employers and employees[2].

5.1.4.2.3 Implementation of heat-health plans in healthcare facilities

While heat plans find high adoption rates in most health care facilities, with some exceptions (see section 5.1.3.), the actions and protocols should be carried out cautiously by the healthcare personnel. It was pointed out during the interviews, that an important challenge for heat plans lies in the sensibilization of personnel and changes in daily habits (e.g. when it comes to the opening/closing of windows) (Anonymous, 2021a).

5.1.4.2.4 Local implementation of heat-health plans

It is important that at the local level a governance structure is set up in order to create a platform with all stakeholders in the domains of social care, health care, wellbeing, spatial planning, environment and health, education, … In this way the set-up, implementation and evaluation of local heat-health plans can form a basis for many current and future (urban) development projects, realizing health in all policies. The need for a more formal governance and a cross-sectoral approach was identified by Vanderplanken et al. (2021) in their study of European heat-health plans. The identification of key stakeholders can facilitate a broader preparedness and response to heatwaves. Roles and responsibilities of stakeholders should be defined and assigned more clearly to avoid confusion and to improve effective implementation (Vanderplanken et al., 2021).

Regional or federal authorities can also provide local implementations, e.g. in the Netherlands there is tap water publicly available at all railway stations[3].

Citizen science initiatives can be used to derive evidence-based local information but also have great value in creating awareness amongst the participants.

5.1.4.2.5 Communication strategies

Van Loenhout et al. (2016) consulted various stakeholders within the heat-health plans to assess their perceptions on responsibilities, partnerships and the effectiveness of local implementation. They concluded that iindividuals with little social contact do not receive enough attention in the heatwave plans as there are insufficient communication strategies to reach them.

The (to be set up) local governance structure should appoint a central contact point for the general public and to provide information to professionals. The information flow is seasonal, in autumn communication on prevention, preparing measures etc. can be given. During a heatwave the organization might be complex e.g. in timing, but heatwave alerts are most of the time available a few

[1] https://www.risico-info.be/nl/aanbevelingen-voor-werknemers-open-lucht

[2] https://solidarites-sante.gouv.fr/sante-et-environnement/risques-climatiques/canicule

[3] https://nieuws.ns.nl/tap-gratis-water-bij-stations/

days ahead.

Various stakeholders point out that the regular government campaigns and alert systems do not reach risk groups such as young children, elderly, chronically ill people, … In order to reach vulnerable groups it is important to map their social network and to have an overview of organizations and intermediaries through which one can reach them. This is indispensable in order to communicate and provide support targeted and differentiated according to the needs of the different vulnerable subgroups. The interviewed stakeholders have the impression there is insufficient structural policy to fully address the vulnerabilities and to increase climate resilience amongst vulnerable groups.

As mentioned before the federal and regional heat and ozone plans are available on the internet in the **language** of the region. There are no versions available in English or other languages that are frequently spoken in Belgium.

Automated phone warning systems have recently been introduced as an alternative way of communicating warnings to vulnerable subgroups and providing coverage (WHO Regional Office for Europe, 2021). The evaluation of the system as used in Canada, suggests an improvement in individual adaptation to heat and a reduction in the use of health services (Mehiriz et al., 2018).

5.1.4.2.6 Evaluation

There is a need for more detailed studies describing the effectiveness of federal/regional/local heatwave plans on health. Research on the evaluation of the 2003 and 2007 European heatwaves has found no real adaptation to heat (de'Donato et al., 2018). There is also a need to evaluate heat protocols used in a certain setting such as elderly care or care for persons with disabilities. There is a large variation in the implementation degree of heat measures in e.g. residential care facilities for elderly, but the effects on heat-related wellbeing, morbidity and mortality has not been investigated.

The evaluation of behavioural changes due to heat-health prevention and adaptation measures showed that further action is needed to translate knowledge/warnings into heat-adaptive behaviours, especially among elderly people (WHO Regional Office for Europe, 2021).

The setup of pilot projects can be useful if they are implemented and evaluated properly. Successful cases can serve as an example for projects in other places or settings.

5.1.4.3 Indoor thermal climate

Cooling rooms or centres

As mentioned in section 5.1.3.3 some cities and municipalities provide air-conditioned spaces that are publicly accessible during heat waves. It is recommended to further develop these initiatives in other municipalities. However, one should keep in mind that the distance to these cooling centres is limited (see section 5.1.3.3).

Rollout of cooling networks

Currently the energy consumption by air-conditioning systems does not outweigh the energy consumption of heating. However, with increasing hot summers this might become problematic. As mentioned in section 5.1.3.3 the appropriate application of passive cooling techniques helps considerably in keeping heat outside. However, these passive techniques might not be sufficient, hence air-conditioning might become necessary, preferentially coupled to a photovoltaic installation.

With the rollout of heating networks, the opportunity should be taken to also implement cooling networks. In Paris a cooling system has been developed since 1991, the current network of 79 km of grid lines serves 700 mainly public buildings, the network is under development[1]. The cooling system is far more energy-efficient than individual cooling solutions.

[1] https://www.climespace.fr/en/climespace-the-european-leader-of-District-Cooling-and-cold-distribution

Modelling of climate effects on indoor thermal climate

As mentioned in section 5.1.3.3 the indoor temperature is determined by a variety of factors. While there is research on outdoor heat stress, both including measuring and modelling, less studies are available on the impact of climate change on the indoor environment and thermal comfort.

Currently indoor models used for estimating energy use in buildings, perform dynamic simulations with time steps of a year. When accounting for aspects such as thermal comfort and energy use in "smart buildings", it is important to reduce the time steps in the simulations to the order of 15 minutes, this requires much larger computing capacity. This type of indoor-models can be coupled to climate models in order to model thermal comfort under future climate and building circumstances. VITO is currently developing such a CFD-model.

5.1.4.4 Spatial planning: green-blue infrastructures

Overall, there has been a greater focus on benefits of green spaces in the literature, compared to blue spaces. Evidence for reduced health effects for blue infrastructures is however not clear. For example, a recent meta-analysis by Gunawardena et al. (2017) found that inadequately designed blue spaces may actually exacerbate heat stress during oppressive conditions.

In constructing green-blue infrastructures, socio-economic factors also need to be taken into account. There is some Europe-wide evidence of inequalities in access to green and blue spaces among the European regions and cities (Poelman, 2018). Eurofound, the European Foundation for Improvement of Living and Working Conditions[1], provides links between socio-economic status and perceived access to green space in European countries based on the European Quality of Life Survey (2018). These data have been used in the recent WHO assessment report on environmental health inequalities in Europe (WHO Regional Office for Europe, 2019). The analysis of the relationship between socio-economic status and access to and use of green space, especially in urban environments, would be helpful for local policies aimed at delivering a more equal distribution of the benefits of such spaces across society. Associated to this, urban greening initiatives can drive **gentrification**. The significant increases in housing prices resulting from gentrification can contribute to the displacement of low-income residents, especially house renters, who can no longer afford to live in rapidly gentrifying neighbourhoods (Easton et al., 2020). The aspect of gentrification is not addressed in the plans discussed in section 5.1.3.4.

The availability of **open-water swimming areas** is limited in Belgium, certainly in urban areas. The conditions for operating a swimming site are very strict: good water quality, implementation of various safety aspects, the site must be operated and a lifeguard must be present. Also, all navigable waterways do not qualify. These conditions are similar in the Flemish and Walloon legislation. The obligation to operate and the principle of liability (the operator is responsible in case of accident) are one of the main reasons why few permits are issued. Some Flemish cities are taking initiatives to create swimming zones, but exploitation costs are high[2]. In other countries, the government provides infrastructure to guarantee safety and information is given on the possible risks. In addition to the government's duty to inform, the individual bears the risk.

The health-risks associated with water in public spaces is discussed in section 5.3.3.5.

[1] https://www.eurofound.europa.eu/data/european-quality-of-life-survey

[2] https://www.vrt.be/vrtnws/nl/2020/08/17/zwemmen-in-open-water/

5.2 VECTOR-BORNE DISEASES

Vector-borne diseases are human illnesses caused by parasites, viruses and bacteria that are transmitted by vectors. Vectors are blood-feeding anthropods (such as mosquitoes, ticks, and fleas) that can transmit infectious pathogens between humans, or from animals to humans.

The transmission possibilities of these vector-borne diseases are determined by the presence of the vector, its survival and reproduction rate, the time of year and level of vector activity, the rate of development and reproduction of the pathogen within the vector.

The distribution and survival chances of both vectors and pathogens may be altered by changes in both climate-related factors and non-climate related factors. Amongst climate-related factors are changes in season's length, precipitation, humidity and temperature. Non-climate factors include environmental changes such as land use and land coverage, deforestation, land clearance, urbanization. But the vulnerability to vector-borne diseases also depends on good and population mobility (trade and travelling), living conditions and human behavior (De Ridder et al., 2020). In this report, we focus on infections transmitted through bites from mosquitoes and ticks, being the most prevalent vector-borne diseases in Belgium. It is to be mentioned, that climate change is also thought to have been a factor in: the expansion of *Phlebotomus* sandfly species, which transmit diseases including leishmaniasis.

5.2.1 Current situation

5.2.1.1 Ticks and tick-borne diseases

Tick borne diseases, such as tick-borne encephalitis (TBE) and Lyme disease, currently constitute the greatest vector-borne disease risks in Europe. Tick diseases affect all age groups and particularly people between the ages of 45 and 65 years. In Belgium only about 14% of ticks are infected with *Borrelia burgdorferi sensu lato (s.l.), the causative agent of Lyme borreliosis* (Lernout et al., 2019).

The two main determinants of tick survival are (1) a suitable environment (areas with moderate to high rainfall and vegetation) and (2) the presence of a wide variety of hosts, for the different stages of the tick's life cycle. Ticks can survive cold winters but become active when the ambient temperature increases above 4-5°C. Higher temperatures are needed for metamorphosis and egg hatching, i.e. between 8°C and 10-11°C respectively. Very hot months can have a negative effect on tick activity and survival. The optimum activity range is between 18 and 25°C (Gray et al., 2009). Belgian reporting data on tick bites on humans (see section 5.2.3.1) are available for the period 2015 – present. Figure 5-9 shows the number of weekly tick bite notifications for this period. There is so far no clear time trend over the years, but there is a clear seasonal trend, most tick bites are reported in the period March to October with a peak in June.

Figure 5-9. Number of reported tick bites on humans per week over the period 2015 – present. Source: TekenNet/TiquesNet[1].

[1] https://epistat.wiv-isp.be/ticks/

Long dry periods and/or exceptionally warm temperatures can have a negative effect on tick activity and survival, hence causing decreases in the number of tick bites reported (as was the case e.g. May/June 2017 and 2019) (Lernout et al., 2019). Further surveillance of the counting data shows that the majority of tick bites occurs within a distance of 10 km from home and are primarily associated with leisure activities in gardens and forests (Lernout et al., 2019).Lyme disease is caused by *Borrelia burgdorferi s.l.*. The network of sentinel laboratories weekly reports the number of positive serological tests (Western Blot) for *B. burgdorferi s.l.* (see section 5.2.3.1). Figure 5-10 shows the number of weekly positive tests for the period 2013-2019. The seasonal pattern is clearly visible, the number of Lyme infections in Belgium has remained relatively stable over recent years.

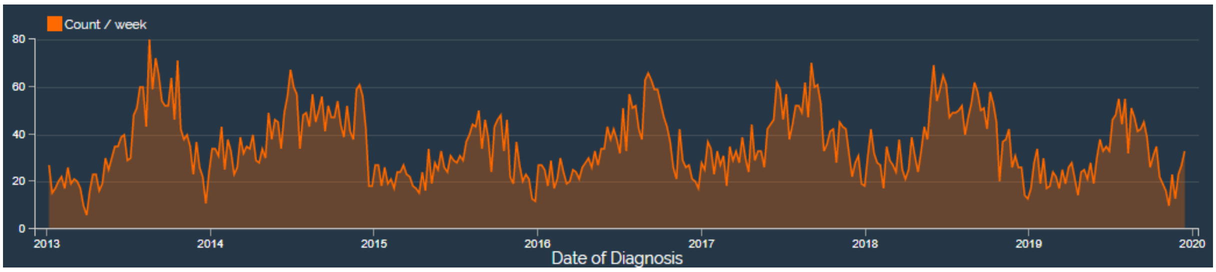


Figure 5-10 Number of reported positive serolotical tests for B. burgdorferi s.l. per week over the period 2013-2020. Source: Epistat/Epilabo – Sentinel Laboratories Network[1].

The surveillance data show that the highest number of positive results were found in forested areas, in the provinces of Antwerp, Limburg, Brabant and in the Ardennes[2].

Overall, for the period 2015-2017, it was estimated that about 11,000 people yearly consulted the general practitioner for an erythema migrans, a red expanding rash at the site of the tick bite, often seen in the early stage of Lyme borreliosis (Geebelen et al., 2019). Following a tick bite, the risk of developing Lyme borreliosis ranges between 1% and 3% in the Netherlands (Hofhuis et al., 2017).For Belgium no risk numbers are available. According to the Minimal Hospital Registrations (MHD/RHM/MZG), yearly about 200 to 300 patients are hospitalized due to Lyme borreliosis. These surveillance data show that Lyme borreliosis is endemic since many years in Belgium (Lernout et al., 2018).

TBE is a viral tick-borne disease, transmitted to humans by *Ixodes ricinus* ticks. TBE is currently endemic in Central Europe, Baltic region, Russia and part of eastern Asia. However, due to the mix of socio-economical, ecological and climatic factors as well as more susceptible hosts, improved diagnostic capability and medical awareness, the epidemiology of TBE is changing (Riccardi et al., 2019). In Belgium, endemic foci have been identified in the past decade, calling for improved surveillance in ticks, and humans at risk, and sentinel animals (Roelandt et al., 2014). Tick-borne encephalitis virus (TBEV) has been suggested to circulate in Belgium based on results from seroprevalence studies in animals (Roelandt et al., 2017). In 2018, the two first human TBE-cases with possible/probable autochthonous infection were reported. In 2020, three autochthonous infections with TBEV have been reported (Suin et al., 2021). Finally, some pathogens, causing disease in humans such as *Candidatus* Neoehrlichia mikurensis, have been detected in ticks removed from humans (Lernout et al., 2019). In the absence of routinely available diagnostic tests, however, no human infections have been reported in the country so far. Vulnerable groups of contracting ticks are all people who regularly come into contact with nature, either professionally or during leisure time.

[1] https://epistat.wiv-isp.be/dashboard/
[2] https://epistat.wiv-isp.be/dashboard/ , select pathogen Borrelia burgdorferi (Lyme)

5.2.1.2 Mosquitoes and mosquito-borne diseases

The main diseases that are transmitted to human by mosquito bites include Zika, West Nile fever, Chikungunya, dengue, and malaria. These different pathogens are transmitted by different types of mosquitoes.

Our common mosquito ***Culex pipiens*** and the newly appearing in Belgium mosquito *Culex modestus* are the main vectors for the **West-Nile Virus** (WNV) in Europe (Chaskopoulou et al., 2016). Most WNV infections in humans are asymptomatic. About 20% of WNV infections in humans may cause West Nile fever and less than one percent may cause West Nile neuroinvasive disease (Sambri et al., 2013). The following information was taken from a recent publication of Bakonyi and Haussig (2020) on the movement of the WNV in Europe: in 2020, the WNV caused remarkable outbreaks in certain areas in Europe, such as Spain and the Netherlands. The largest outbreak of human WNV infections in European Union/European Economic Area (EU/EEA) countries was recorded in 2018, when 11 countries reported 1,548 locally acquired mosquito-borne infections. The highest number of newly affected areas (n = 45) was reported. Even though in 2019, the number of reported locally acquired human WNV infections dropped by 73% compared with 2018, the total numbers were still the second highest ever recorded. Most countries reported numbers of infections similar to before 2018, while Greece continued to report high numbers of infections so far, no autochthonous cases have been diagnosed in Belgium (Bakonyi and Haussig, 2020). According to Institute Tropical Medicine (ITM), Belgian native mosquitoes, such as *Culex pipiens* are possibly already infected with the West-Nile virus (WNV) (ITM, personal communication March 2021). So far no autochthonous human infection has been diagnosed in Belgium.

The Usutu virus (USUV) appeared in Belgium in 2017 and 2018 (Benzarti et al., 2020), no autochthonous human infection has been diagnosed in Belgium.

The introduction of exotic vector mosquitoes in Europe in the last decade has substantially increased the threat of (re)emerging mosquito-borne diseases**. *Aedes* mosquitoes** are well known invasive species, able to disperse into new areas and countries. These mosquitoes can adapt to wide-ranging circumstances and are associated with human-made habitats, allowing them to spread in populated, urban areas. Eggs of *Aedes* mosquitoes are often transported via the global trade of goods, particularly used tyres (cars, trucks, heavy vehicles) and 'lucky bamboo' plants. The introduction and establishment of *Aedes* mosquito species into Europe is a growing problem. Of most concern is the rapid expansion of the geographical range of ***Aedes albopictus*** which is already widespread and abundant in the Mediterranean basin, where it is causing biting nuisance and has been implicated as a vector in the local transmission of mosquito-borne diseases. Indeed, *Ae. albopictus* mosquitoes are known as effective vectors of pathogens such as dengue and chikungunya viruses. In fact, an increasing number of outbreaks of these mosquito-borne diseases have been reported in the last five years in southern Europe. Travellers returning from disease-endemic countries may introduce the diseases into new areas where these mosquitoes are establishing themselves, increasing the risk of onwards autochthonous transmission.

In Europe, various mosquito-borne diseases have occurred in the past decade, outbreaks of West Nile fever, but also dengue in France, Croatia, Spain and Portugal (Madeira), malaria in Greece, and Chikungunya in Italy and France (ScienceDaily, 2019). *Aedes albopictus,* the tiger mosquito, is the main vector in Europe of chikungunya, dengue and zika. Aside its potential to become a serious health threat as a bridge vector of zoonotic pathogens to humans, it is also known to be a significant biting nuisance.

In Belgium the MEMO project has monitored exotic mosquitoes in Belgium from 2017 till 2020 by setting up traps in 23 points of entry (Deblauwe et al., 2020). Aedes species were found episodically in different locations in Belgium, an overview is given in table 55 Table 5-5.

Table 5-5. Overview of exotic mosquitoes spotted and/or so far collected in Belgium. Source: Deblauwe et al. (2020).

Aedes mosquitos		**Spotted in**	**First time spotted in Belgium**	**Afterwards spotted?**	**First time captured**
Asian Tiger mosquito	Aedes albopictus	East-Flanders, Hainaut, Namur, Luxembourg	2000	Sporadically, every year	
Asian forest mosquito	Aedes japonicus	Namur, Liège	2002 in Namur	Control measures 2012-2015. Spotted in Namur 2017	2017, German border
	Aedes koreicus	Near Maasmechelen	2008	Well established population in area of 113km^2	
	Aedes pharoensis	Liège	2017, one at Liège airport	Small survival rate due to inappropriate temperature climate	

5.2.2 Expected changes

Ticks and mosquitoes are sensitive to climatic factors, and consequently climate change could alter their prevalence (range) or occurrence of outbreaks. Due to climate change, land use changes and increased travel and trade, it is expected that novel and unusual outbreaks of vector-borne diseases will occur in Europe over the next few decades, with a risk of these diseases becoming endemic. Mosquitoes and ticks have proliferated, adapted to different seasons, and invaded new territories across Europe over the past decade, with accompanying outbreaks of potentially severe diseases.

While non-endemic vector borne diseases are of concern due to the introduction of a new disease, endemic vector-borne diseases are also a concern under climate change due to an expansion in the number of people that can be potentially exposed (Otten et al., 2020).

5.2.2.1 Ticks and tick-borne diseases

Climate change will cause warmer winters in Belgium (see section 2.1), this might increase tick prevalence and tick activity (and hence of Lyme borreliosis) in Belgium. However, also the humidity of the environment plays a role as ticks prefer microclimatic conditions with high humidity. In their prolonged nonparasitic phases, they require a microclimatic relative humidity of at least 80% to avoid fatal desiccation (Gray et al., 2009). The impact of climate change on the incidence of Lyme borreliosis is thus not a simple linear one. It is possible that in Belgium where lowered summer precipitation coincides with raised summer temperatures, the survival, activity and distribution of ticks are likely to be reduced (Gray et al., 2009).

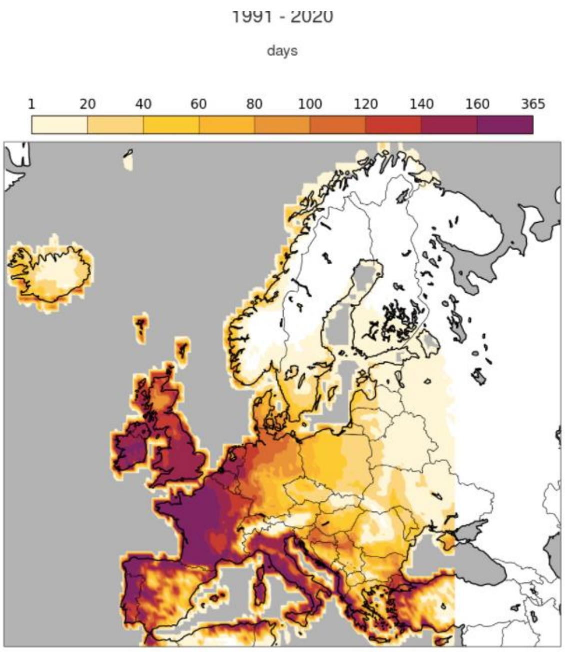
An increase in the number of cases of Lyme disease since the start of the 1990's has been observed in Belgium (42 reported cases in 1991 vs. 722 reported cases in 2003), yet the estimated annual incidence of 2015-2017 was comparable to the incidence of 2008-2009 (Geebelen et al., 2019). In the Netherlands the number of reported cases of Lyme disease has tripled between 1999 and 2014 (Wuijts et al., 2014). Other factors than climate change may be at play, such as changes in human behavior, awareness rising through information campaigns, better reporting systems. Also changes in nature policy can influence the area of suitable habitats for ticks.

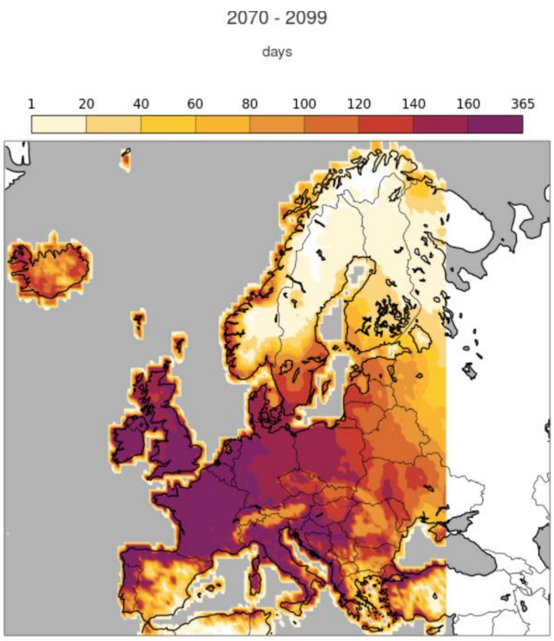
5.2.2.2 Mosquitoes and mosquito-borne diseases

Considering the exotic mosquitoes, mainly globalization (traffic and trade) causes them to enter our country. Increasing temperatures make them survive longer, reproduce in summer and may even

survive winter. There is therefore an increased risk in mosquito borne diseases, such as West Nile fever, dengue, Chikungunya, malaria and Zika. Climate change predictions suggest *Ae. albopictus* will continue to be a successful invasive species that will spread beyond its current geographical boundaries (ECDC, 2012a, 2009; Gould and Higgs, 2009). This mosquito is already showing signs of adaptation to colder climates which may result in disease transmission in new areas (Kraemer et al., 2015; Paupy et al., 2009). *Aedes japonicus and Aedes koreicus* mosquitoes are already established in Belgium (Versteirt et al., 2012). The chance that those species are infected is very small, however *Aedes japonicus* is a potential vector for the WNV (ITM, personal communication March 2021).
The exotic *Aedes* mosquitoes will probably become a threat for Belgium in the coming years. Based on the current spread of *Aedes* spp. particularly in our neighbouring countries, on the number of interceptions of these species in Belgium, and on the suitability models developed for *Ae. albopictus* in Europe, introduction and establishment of *Ae. albopictus* in Belgium is likely to occur. Punctual introductions of the tiger mosquito (*Aedes albopictus*) have namely repeatedly been reported during previous years.

For the Aedes albopictus in order to reflect the survival chance and seasonal activity of the tiger mosquito, two indicators have been developed within the Copernicus Climate Change Service (C3S)[1]. The suitability index reflects the survival chance of the tiger mosquito which is determined by annual rainfall, summer temperatures and January temperatures. The mosquito season starts when the insect's eggs hatch after winter and continues until the eggs are no longer hatching in autumn. The length of this season is determined by temperature statistics and hours of sunlight[2]. For these indicators maps have been produced under different RCP scenarios. The data covers the period 1971 to 2099 and statistics are averaged for 30 years in overlapping time periods set 10 years apart. *Figure 5-11* shows the data for the season length (in days) and the suitability index (in %) under the RCP 8.5 scenario for the time periods 1991 – 2020 and 2070-2099.





[1] https://cds.climate.copernicus.eu/apps/c3s/app-health-aedes-albopictus-suitability-projections
[2] https://climate-adapt.eea.europa.eu/metadata/indicators/climatic-suitability-for-the-tiger-mosquito-season-length-1971-2099

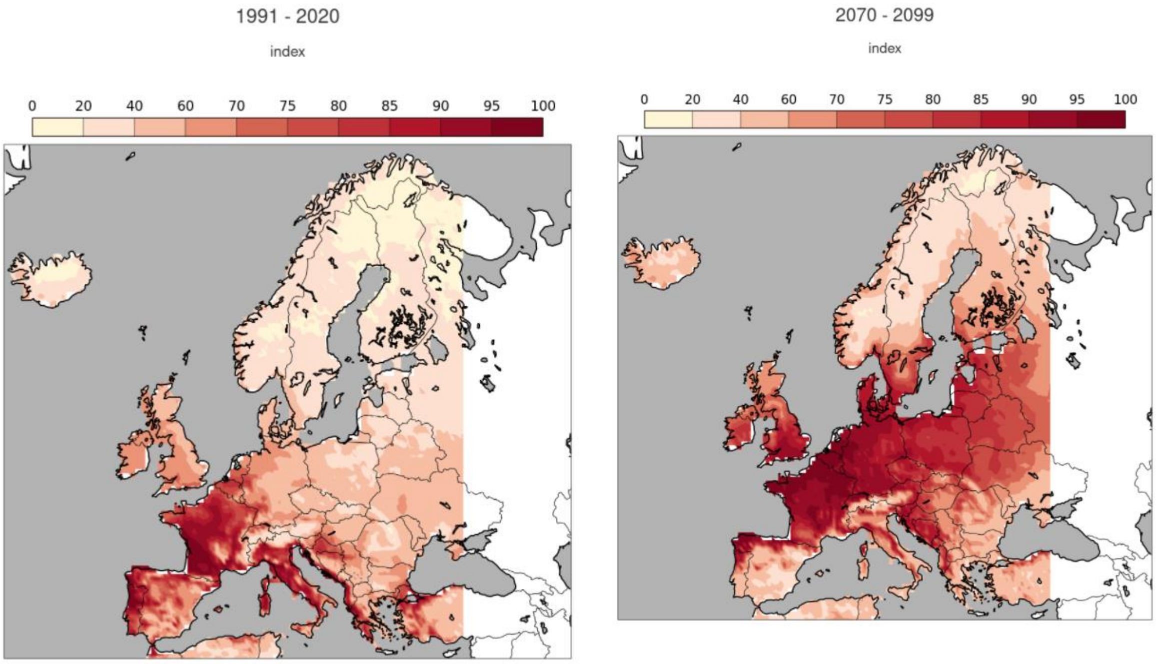


Figure 5-11. Projected change in season length (in days) (upper panels) and the suitability index (in %) (lower panels) for Aedes albopictus, for the periods 1991-2020 (left) and 2070-2099 (right). Source: Climate Data Store Copernicus Climate Change Service.

For these indicators maps have been produced under different RCP scenarios. The data covers the period 1971 to 2099 and statistics are averaged for 30 years in overlapping time periods set 10 years apart. Table 5-5 shows the data for the season length (in days) and the suitability index (in %) under the RCP 8.5 scenario for the time periods 1991 – 2020 and 2070-2099.

Climate change has previously not been expected to have a significant impact on WNV transmission in Europe (Gale et al., 2010; Gould and Higgs, 2009). However, climate change could influence the transmission of the virus by affecting the geographical distribution of vectors and pathogens, by changing the migratory patterns of bird populations and through changes in the life cycle of bird-associated pathogens. Temperature increases could also play a role. The WNV risk in Europe has been projected into 2025 and 2050, with July temperature projections under a medium emissions scenario (IPCC Special Report on Emissions Scenarios (SRES) A1B), keeping other variables constant (e.g. state of vegetation, water bodies and bird migratory routes), see Figure 5-12 (Semenza et al., 2016). The results reveal a progressive expansion of areas with an elevated probability for WNV infections, particularly at the edges of the transmission areas. Projections for 2025 show an increased probability of WNV infection in East-Central Europe, high-risk areas will have expanded even more by 2050.

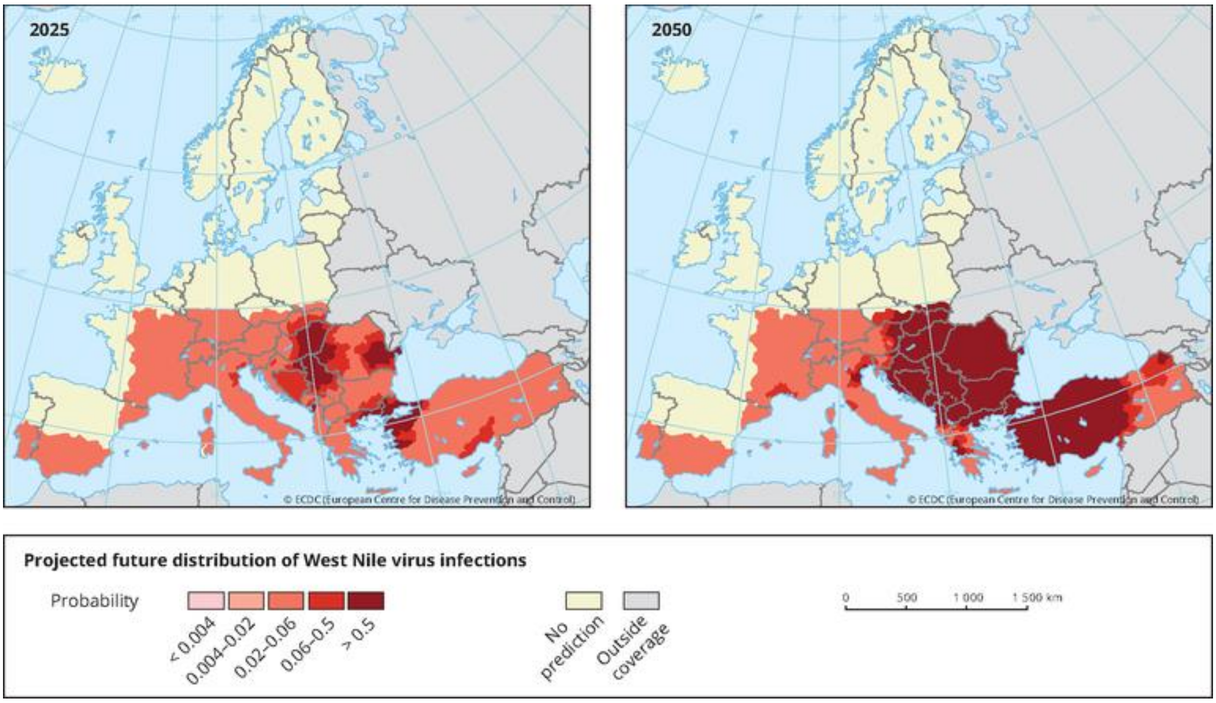


Figure 5-12 Projected future distribution of West Nile Virus infections. Source: [1].

The risk of chikungunya may increase in Europe, particularly in those regions where the seasonal activity of Aedes albopictus aligns with the seasonality of endemic chikungunya infections abroad, thereby potentially increasing the risk of importation via travelers *(Charrel et al., 2008)*. Figure 5-13 shows model results of chikungunya transmission in Europe under climate change scenarios. France, northern Italy and East-Central Europe are identified as the areas at highest risk, with increases in the level of risk in much of western Europe, including the Benelux countries and Germany (Fischer et al., 2013).

[1] https://www.eea.europa.eu/data-and-maps/indicators/vector-borne-diseases-2/assessment

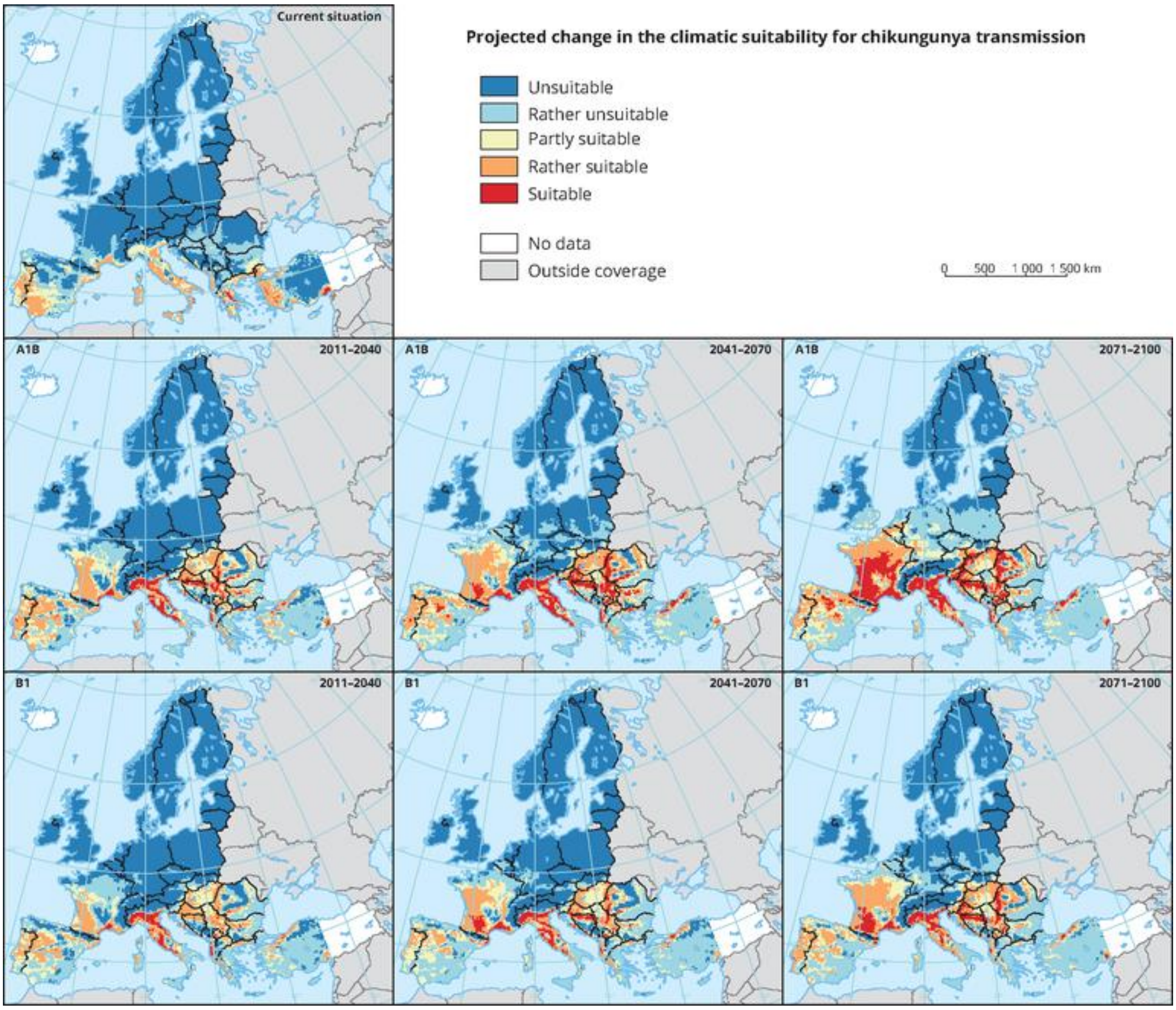


Figure 5-13 Projected change in the climatic suitability for Chikungunya transmission. Source: [1].

5.2.2.3 Non-climate related changes

The current COVID19 pandemic also indicated the increased population risk because of **frequent travellers and globalization**. Similar to temperature-related effects, elderly individuals and those in lower socio-economic groups are at higher risk from these pathologies because of increased prevalence of pre-existing health issues (such as chronic conditions).

[1] https://www.eea.europa.eu/data-and-maps/indicators/vector-borne-diseases-2/assessment

5.2.3 Current and planned measures

5.2.3.1 Data availability on ticks, mosquitoes and pathogens carried by those vectors

5.2.3.1.1 Monitoring and surveillance of the current Belgian situation

Ticks and tick-borne diseases

In Belgium a reporting system for tick bites on humans was set up in 2015, through an interactive website and app (TekenNet/TiquesNet[1]) where citizens can report them. This is an initiative of Sciensano with collaboration of the three Belgian communities, hence covering Belgium in total. The interactive data-module Epistat[2] allows to analyze the data from TekenNet/TiquesNet and to obtain information on time trends, geographical spread of the reported tick bites, environments in which they often occur, and the distance to the home location. Sciensano annually reports the results of this surveillance (Lernout et al., 2018). In 2017, citizens were also asked to send the ticks they removed from their body to Sciensano, between April 1st and October 31st. The collected ticks were screened by PCR for the presence of several tick-borne pathogens (Lernout et al. 2019). This study is currently being repeated, until October 31st 2021.

A citizen science project 'Teek a Break'[3], started in March 2021 by the University of Antwerp in cooperation with 'Mijn Tuinlab'. Participants collect ticks in a systematic way in their gardens, the type of tick and its pathogens load is examined. Within the framework of TekenNet/TiquesNet Sciensano a similar initiative is launched as a follow-up of a previous initiative carried out in 2017.

Passive surveillance of ticks is in place through the Belgian nature platform Waarnemingen.be[4], people can report the occurrence of rare and/or invasive exotic plant and animal species, such as ticks and mosquito types. This type of passive surveillance is less effective than active surveillance. The organization cooperates with the Belgian regions, reports of invasive exotic species quickly reach land managers and competent authorities.

There are three information sources for surveillance of tick-borne diseases in Belgium. First, a network of sentinel general practitioners allows to estimate the number of patients consulting a general practitioner with an erythema migrans. Furthermore, the number of positive serology tests for antibodies to Borrelia burgdorferi s.l. (Western Blot) is reported every week by a network of sentinel laboratories (section 3.6.6), these results are shown in an interactive data-module Epistat[5] where you can select the pathogen Borrelia burgdorferi (Lyme). The National Reference Centre for Borrelia of UCL-UZLeuven provides support in the diagnosis of Lyme borreliosis; in addition to serological tests, they also perform more complex tests (PCR, species identification, CXCL13). The number of people hospitalised for Lyme disease is registered via the Minimal Hospital Data of the Federal Public Service Health.

A recent study on Agency Nature and Woods (ANB) staff members, showed that none of them had antibodies against the tick-borne encephalitis virus, indicating a history of infection through exposure to the virus (Lernout et al., 2019). This does not mean that the virus is not present in Belgium, but that the risk of infection is very low, even in people who are frequently exposed to tick bites.

[1] https://tekennet.sciensano.be/
[2] https://epistat.wiv-isp.be/ticks/
[3] https://www.uantwerpen.be/nl/projecten/teek-a-break/over-het-tekenprojec/).
[4] https://waarnemingen.be/
[5] https://epistat.wiv-isp.be/dashboard/

Mosquitoes and mosquito-borne diseases

Currently (June 2021) there is no running mosquito monitoring in Belgium. Since 2017 mosquitoes were monitored within the MEMO project (2017-2020). This project was performed by the Institute of Tropical Medicine Antwerp (ITM), the Royal Belgian Institute of Natural Sciences (RBINS), the Royal Museum for Central Africa (RMCA), and Barcoding of Organisms and Tissues of Policy Concern (BopCo). Monitoring was done at 23 locations in Belgium, focusing on the most likely first entry points for exotic mosquitoes. These locations include companies trading in second-hand tires, lucky bamboo importers, ports, airports and parking areas along the Belgian border. With the support of Avia-GIS, the VECMAP information system is used for the integration of field and laboratory data[1].

The virus-load is not routinely monitored in Belgium. Recently, Wang et al. (2021) characterized for the first time the virome of native mosquitoes collected in the surroundings of Leuven, resulting in the identification of at least 33 eukaryotic viral species. Nine (near-) complete genomes belonging to 6 viral species were identified, all of which were closely related to known (but not explicitly mentioned) viruses.

Several citizen science projects exist in Europe in order to investigate and control disease-carrying mosquitoes, e.g. on a European level Mosquito Alert[2] within the AIMsurv project[3], as well as on a country level in the Netherlands[4], France[5], UK[6] etc. In Belgium Sciensano is planning to develop an app in order to report mosquitos, it is expected to become operational beginning 2022. This initiative will update the understanding of their status, distribution and abundance.

For some notifiable infectious mosquito-borne diseases (e.g. chikungunya, dengue, malaria, West Nile fever, zika) mandatory reporting is in place and performed by the regional health authorities (AZG, AVIQ, COCOM).

A surveillance of mosquito borne diseases is in place in Belgium through the National Reference Centres for Arboviruses and malaria. Weekly data are available on the Epistat dashboard for Belgian Infectious Diseases for Chikungunya.

Within the One World, One Health concept, besides the monitoring of humans, it is also of importance to monitor the vectors and their pathogens in animals. Agentschap Natuur & Bos (ANB) and Cellule interdépartementale Espèces Invasives (CiEi) of SPW monitor the health of wildlife both through active and passive monitoring of certain pathogens in animals[7]. This allows to early detect the presence of exotic pathogens and to follow their distribution and prevalence. Results from the occurrence of TBE in wild boar in the period 2020 – March 2021 will be published soon[8], preliminary results show an increase in the circulation of TBE. The monitoring will be repeated within a few years in order to assess the evolution.

5.2.3.1.2 *Monitoring and surveillance of the current European situation*

Ticks

VectorNet is a joint project of the European Food Safety Authority (EFSA) and the ECDC. It provides detailed maps of surveillance activities and current known distributions of various tick species in

[1] https://www.itg.be/E/memo-mosquito-monitoring

[2] http://www.mosquitoalert.com/en/

[3] https://www.aedescost.eu/aimsurv

[4] https://www.nvwa.nl/onderwerpen/muggen-knutten-en-teken/aziatische-tijgermug

[5] https://tiger-platform.eu/fr/moustique-tigre/

[6] https://www.gov.uk/government/publications/mosquito-surveillance/mosquito-nationwide-surveillance

[7] http://biodiversite.wallonie.be/fr/invasives.html?IDC=5632; https://www.natuurenbos.be/beleid-wetgeving/overlast-schade/ziekten-bij-het-wild-levende-dieren/monitoring-van-ziekten

[8] https://www.natuurenbos.be/beleid-wetgeving/overlast-schade/wildedierenziekten/surveillances/everzwijn-bewaking-op-ziekte-van

Europe and neighbouring regions. The latest maps of distributions at regional administrative level are available online, see e.g. Figure 5-14. Current distribution of Ixodes Ricinus in Europe at regional administrative level, as of March 2021. Source: ECDC and EFSA, n.d. .Figure 5-14 (ECDC and EFSA, n.d.).

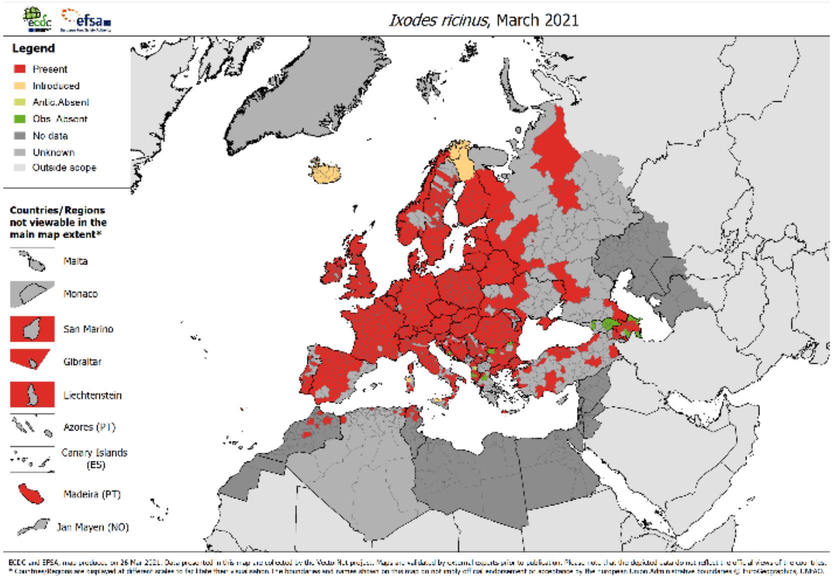


Figure 5-14. Current distribution of Ixodes Ricinus in Europe at regional administrative level, as of March 2021. Source: ECDC and EFSA, n.d. .

Mosquitoes and mosquito-borne diseases

VectorNet has detailed maps of surveillance activities and current known distributions of various tick species in Europe and neighbouring regions. The latest maps of distributions at regional administrative level are available online, see e.g. Figure 5-14. Current distribution of Ixodes Ricinus in Europe at regional administrative level, as of March 2021. Source: ECDC and EFSA, n.d. .Figure 5-15 (ECDC and EFSA, n.d.).

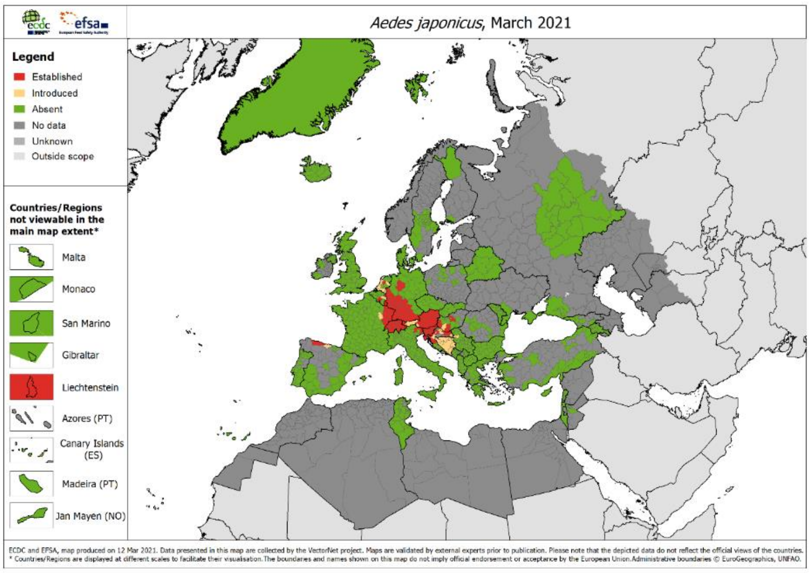


Figure 5-15. Current distribution of Aedes japonicus in Europe at regional administrative level, as of March 2021. Source: ECDC and EFSA, n.d..

For the monitoring of WNV ECDC applies the One World, One Health approach, including human cases of WNV infection as well as outbreaks among equids or birds. ECDC publishes weekly WNV epidemiological updates during the WNV transmission season (usually between June and November), including the geographical distribution of human cases in the EU/EEA and EU neighbouring countries[1]. This information is essential to support the national authorities responsible for blood safety in the implementation of the EU blood safety directives. In addition, ECDC publishes maps highlighting areas where WNV outbreaks among birds have been reported.

5.2.3.2 Information, sensibilization and prevention

Ticks and tick-borne diseases

Preventive measures for spreading tick-borne diseases include bite prevention, e.g. by wearing covering clothes or using insect repellant, daily control and removal of ticks. Furthermore, early detection of symptoms after a tick bite, is important as it allows prompt treatment which prevents more serious cases of disease. For Wallonia, AVIQ has an information and sensibilization campaign based on the four actions: prevention, inspection, reaction and surveillance. They developed a poster and a flyer[2] that is distributed via pharmacies, general practitioners and also by youth movements. The ENVIeS-plan foresees an action to further distribute brochures for prevention and awareness rising, billboards will be installed at the edge of forest in order to reach out to walkers in the forest (SPW Environnement-santé, 2019).

Similarly, Flanders AZG has a sensibilization campaign with information available online[3], and they provide educational materials for schools (primary schools and secondary schools separately), as well as for, amongst others, youth movements and parents.

The latter groups are particularly of importance since, as mentioned in section 5.2.1.1, most reported tick bites are contracted within a perimeter of 10 km from home, in the garden and in the forest, and this mainly during leisure activities. Vulnerable groups from a professional point of view such as employees of green services, foresters, nature guides, farmers, etc. are not addressed particularly in the information and sensibilization campaigns.

However in the aforementioned study by Lernout et al. (2019) a survey of forest workers showed ethat there is still room for improvement of prevention, especially through the use of repellents and tucking in the stockings/boots. Regular repetition of prevention measures and recommendations for the control of tick bites and the correct removal of ticks, as well as information about possible diseases that can be transmitted by ticks, is useful.

The Superior Health Council provided an advice on the need for vaccination against TBE in February 2019 (HGR, 2019a). In the current epidemiological situation in Belgium (sporadic human cases, geographically distributed), vaccination (except for travelers) is not recommended, even for professional (loggers, foresters...) or recreational risk groups.

Information on risk factors, such as human behavior and the spatio-temporal dynamics of tick bites among the Belgium population, as collected via the Tekennet/Ticknet platform, allows to perform region- or habits-oriented prevention campaigns[4].

Mosquitoes and mosquito-borne diseases

Preventive measures for mosquitoes are avoiding breeding in stagnant water, use of insect screens for windows, and use of repellent sprays or mosquito nets. Mosquitoes lay their eggs in stagnant water. Therefore, one needs to get rid of left-over water in: buckets, flower pots, clogged gutters, wheelbarrows, tires, plastic netting, litter. Prevention can be done by covering rain barrels with

[1] https://www.ecdc.europa.eu/en/west-nile-virus-infection

[2] https://www.faimes.be/actualites/morsures-tiques-prevention-2021.pdf

[3] www.tekenbeten.be

[4] https://ticknet.sciensano.be/project

mosquito netting, regularly changing the drinking bowls of pets.

The MEMO-website of ITG[1] and SPW[2] give information on mosquitoes and advice on how to prevent them. In countries where the Aedes albopictus occurs, sensibilization campaigns are set out; e.g.: France[3], Netherlands, UK.

Aside from small stagnant water parts, larger still water areas may have the problem of mosquito growth. The latter can be partly overcome by some measures, that are different depending on the mosquito species. In general, lack of vegetation, presence of predators (fish), direct sunlight, limitation of faecal input and algae, and avoidance of drying in i.e. water level fluctuation were described to avoid mosquitoes. These measures were described by Medlock and Vaux (2014) to avoid mosquito development. In this respect, there is some concern about wadis, areas which are intermittently filled with rainwater, and functions as a buffer to let the water slowly infiltrate into the ground. This needs to be further looked into.

The Superior Health Council provided recommendations for travellers to areas with local transmission of the zika virus in November 2019 (HGR, 2019b).

5.2.3.3 Local implementation

The majority of Belgian cities and municipalities disposes of an energy and climate plan as detailed in section 4.2.4. These plans sometimes mention prevention measures against ticks, no measures against mosquitoes are mentioned. Management measures at a local level for ticks include mowing policy and the installation of dry borders in private gardens as well as in public domain managed by the municipality.

For Flanders, AZG in collaboration with Sciensano has set up a tick risk maps with a risk assignment (very high, high or moderate) for every community, these maps will be implemented in 2022. It is not possible to develop these maps at a higher spatial resolution, indicating risk areas within a community, because the data sources used are only available at the community level. The methodology used cannot be transferred directly to Wallonia as the data sources used (e.g. presence of deer) differ between Flanders and Wallonia.

5.2.3.4 Information flow to medical practice

Concerning TBE the Superior Health Council (HGR, 2019a) gives advice for physicians for three situations:

- In case of no human cases - low circulating TBE virus level: no active surveillance;
- In the case of sporadic human cases (at irregular intervals or in a few places; geographically
- only in a few places; geographically dispersed): inform medical doctors (Belgium-wide);in case of 2 or more human cases in the same year in the same area (natural park): inform medical doctors(Belgium-wide).

The information flow and communication channels on other infectious diseases are covered in section 6.1.3.1.

E-learning modules are currently being developed through NEHAP and will give healthcare professionals a more in-depth formation on problems related to climate change and other environmental stressors, this is further detailed in section 6.1.3.1.

To prevent transfusion-transmitted WNV infections, a blood donor deferral period or testing of prospective donors who have visited or live in an affected area[4] has to be respected. In affected areas, blood establishments must follow recommendations provided in the EU preparedness plan for blood

[1] https://www.itg.be/N/memo-muggenmonitoring

[2] http://biodiversite.wallonie.be/fr/le-moustique-japonais.html?IDC=6000

[3] https://www.anses.fr/fr/content/le-moustique-tigre; https://www.eid-rhonealpes.com/luttons-ensemble-contre-le-moustique-tigre

[4] https://www.ecdc.europa.eu/en/west-nile-fever/facts

safety[1] (see also section 5.2.3.1.2).

In contrast to the heat-health plans, Table 5-6 indicates that protocols for vector-borne disease have much lower rates of implementation across types of health care institutions (Anonymous, 2021b).

Table 5-6. Results from online survey for the question 'Does your institution have a plan or protocol which is active when a vector-borne disease is identified?'

	Yes	No, ad hoc adaptation of activities while working on a heat plan	No, ad hoc adaptation of activities and increased vigilance	No protocol or adaptation
General hospitals	32%	21%	37%	11%
University hospitals	100%	0%	0%	0%
Psychiatric hospital	50%	0%	40%	10%
Institution for persons with disabilities	24%	4%	65%	7%
Elderly care home	57%	17%	27%	0%
Rehabilitation hospital	50%	0%	50%	0%

5.2.3.5 Control measures of mosquitoes

In case exotic mosquitoes are detected, it is important to eradicate the larvae, mosquitoes and their reservoirs in order to prevent further spreading. The regional authorities (ANB for Flanders, SPW – Cellule interdépartementale Espèces invasives (CiERi)[2] for Wallonia) are responsible for the eradication, this is done in subcontracting (Rentokil for ANB, Avia-GIS for SPW). The ENVIeS-plan foresees an action to continue the surveillance and eradication of mosquitos, both indigenous and exotic (SPW Environnement-santé, 2019).

Saniport has a control function in terms of insect eradication. In airplanes coming from a specified group of countries, Saniport inspects whether eradication measures have been carried out by stewards in the airplane. The ambition exists to carry out inspections based on a more thorough analysis of risks rather than a fixed set of countries, thereby acting in a more preventive manner (Anonymous, 2021a).

5.2.4 Gaps between risks and current/planned measures - Adaptation actions and recommendations

5.2.4.1 Data availability from surveillance and monitoring

It is of importance to continuously collect, assess and distribute data on spatial occurrence, seasonal population dynamics and abundance of both native and invasive mosquito species. As mentioned before various (indigenous) species of mosquitoes can transmit viruses to humans and animals.

The mosquito monitoring project 'MEMO' is currently waiting for a prolongation. A project proposal for an integrated surveillance has been submitted to NEHAP, combining active and passive monitoring of exotic mosquitoes (more specifically *Aedes* species). It would be of interest to cross this information with the *Aedes* borne disease surveillance in human, or to determine the type of pathogens the mosquitoes are infected with.

In order to continuously monitor the situation, an adequate governance structure needs to be set up. The IMCEH has requested that, in addition to the monitoring planned for 2021-2025, structural funding be identified for long-term monitoring after 2025. In Germany the mosquito monitoring program was recently institutionalized, for both native and invasive mosquito species data are collected (Werner et

[1] https://ec.europa.eu/health/blood_tissues_organs/overview_nl

[2] http://biodiversite.wallonie.be/fr/la-ciei.html?IDC=5725

al., 2020). Also in France[1], Germany and the Netherlands[2] continuous monitoring of native mosquitoes is in place.

5.2.4.2 Information and sensibilization

There is an increased population risk because of frequent travellers and globalization. Similar to temperature-related effects, elderly individuals and those in lower socio-economic groups are at higher risk from these pathologies because of increased prevalence of pre-existing health issues (such as chronic conditions). Further prevention and sensibilization is needed, in order to avoid spreading of the disease, and inform about symptoms allowing people to contact/inform medical practitioners or prevention workers as soon as they get infected (cf. COVID tracking and tracing).

5.2.4.3 Information flow to medical practice

Despite the communication channels described in section 5.2.3.4, there is a concern amongst the interviewed stakeholders that there are not enough communication flows between government levels and the healthcare sector. The perception exists that healthcare workers do not receive all newest information on the occurrence and spreading of disease cases identified nationwide and beyond (Anonymous, 2021a).

Many interviewees point out the element of the unpredictability when it comes to risk factors such as vector-borne diseases (Anonymous, 2021a). However, as pointed out in section 5.2.3.1.2 the occurrence of e.g. autochthonous human WNV infections in Belgium can be expected in due time. This **wrong perception** can cause the health sector not to be prepared accordingly. At the same time, there is some worry that the first experience with a new disease will strongly pressure the healthcare system and healthcare professionals. The main risks identified by the interviewees are that – in such an emergency situation – there would not be sufficiently flexible protocols to adjust to the new risks and that communication flows and points of contacts between government levels and the healthcare sector would not be sufficiently clear (Anonymous, 2021a).

We note that the lists of notifiable infectious diseases are not the same in the regions.

5.2.4.4 Spatial planning considerations

The installation of green and blue infrastructures, such as flood plains, natural areas including water, wadis etc., to mitigate flooding and heat, provides possible breeding places for mosquitoes. This can lead to an increase in nuisance mosquito problems. Medlock and Vaux (2014) reviewed field studies conducted in England to assess the impact of newly created wetlands on mosquito colonization in costal, urban and arable habitats. They conclude that a risk assessment should be performed for new wetland projects and that wetland management plans should develop a contingency for mosquito management (through wetland management strategies rather than biocide usage) in the event of an outbreak. In an urban context, mitigation strategies to overcome ticks and/or mosquito breeding need to be taken into account in the planning (e.g. foreseeing predators or fountains to cause movement in otherwise still water parts). (Ligsay et al., 2021).

The ongoing study by the Flemish Department of Environment (see section 5.1.3.4) will address the extent of the problem in Flanders.

5.2.4.5 Control measures of mosquitoes

The regional authorities are responsible for the eradication of exotic mosquitoes, as detailed in section 5.2.3.5. Every region has its own plan and there is no common approach in the eradication. Therefore, it is of importance to set up a common control plan that runs parallel between the regions.

[1] https://www.eidatlantique.eu/page.php?P=139; https://eid-med.org/missions/

[2] https://www.nvwa.nl/onderwerpen/muggen-knutten-en-teken/rol-nvwa/monitoring

5.3 FOOD- AND WATER-BORNE DISEASES

There is an important health impact of food- and water-borne diseases as a result of climate change. Cassini et al. (2016) calculated the impact of it on the European population health, expressed as Disability Adjusted Life Years (DALYs), which allowed to rank the diseases based on the impact on population health. They described that campylobacteriosis was the food and water-borne disease with the highest burden in the EU/EEA with 8.20 (UI: 6.68–10.01) DALYs per 100,000 population, followed by salmonellosis with 3.96 (UI: 3.68–4.26) and infection with Shiga toxin-producing *E. coli* (STEC) with 2.08 (UI: 2.59–3.21). These diseases represented more than 75% of the burden of the food- and water-borne diseases under study and it was estimated that slightly over 2,000 deaths were associated with it in the EU/EEA every year.

5.3.1 Current situation

5.3.1.1 Water-borne diseases

The EU Bathing Water Directive (2006/7/EG)[1] requites monitoring for faecal indicator bacteria *Escherichia coli* and intestinal *Enterococci* to protect bathers against health effects of faecal pollution (EU BWD is e.g. included in Vlarem II, annex 2.3.3). In 2019, in Flanders the water quality of 47 inland bathing waters was perfect (78.7%) or good (14.9%). However this was the lowest percentage of perfect bathing waters, since the start of the yearly testing over 20 years ago (VMM, 2020b). It was indicated this could be due to successive warm and dry summers, causing the water level being low, and therefore increasing the concentration of contaminants. There were in 2019 in the inland bathing waters, five and eleven swimming prohibitions due to respectively too high *E. coli*/ *enterococcus* levels, or the presence of *Cyanobacteria*. *Cyanobacteria*, also called blue-green algae, are bacteria floating on the water surface forming a scrum-like layer or dispured throughout the water column. They proliferate mainly in still nutrition-rich water. Their growth was favored due to the hot temperatures in 2019. The harm of those bacteria is caused by the cyanotoxins they produce or secrete. Those toxins can cause gastrointestinal, neural, hepatic, or dermal toxicity due to inhalation or ingestion (Vilariño et al., 2018). Considering the 42 coastal bathing zones, 97.6% were of perfect quality in 2019. This was similar to the year before, and there was no swim prohibition at the coast. Nevertheless, after strong showers, sometimes the water quality temporarily lowers in the port areas of Oostende, Blankenberghe and Nieuwpoort, where untreated waste water is then discharged due to an overflowing wastewater collection systems (VMM, 2020b).
In Wallonia the bathing water quality was reported to be ameliorated between 2010 and 2018 (Portail Wallonie.be, consulted in April 2021)[2]. Of the 33 bathing zones (18 lakes, 15 rivers), 58% was of excellent quality and 15% had a good water quality. The main causes of bad water quality were, heavy rains increasing the faecal microorganisms' concentration (agricultural runoff, overflowing of storm overflows or wastewater collection systems). Other causes were direct access of livestock to water, and direct discharge of untreated wastewater to water courses.

Considering the quality of public tap water, used for human consumption for drinking, hot drinks preparation, cooking, dish washing, showering and tooth brushing, the same microbiological parameters as for bathing water - *Escherichia coli* and intestinal *Enterococci* - are screened (Guideline

[1]https://ec.europa.eu/environment/water/water-bathing/index_en.html#:~:text=EU%20at%20the%20forefront%20to%20protect%20bathers'%20health&text=The%20revised%20Bathing%20Water%20Directive,parameters%20of%20(faecal)%20bacteria

[2]http://etat.environnement.wallonie.be/contents/indicatorsheets/EAU%2010.html#:~:text=Am%C3%A9lioration%20de%20la%20qualit%C3%A9%20entre%202010%20et%202018&text=5%20zones%20(15%20%25)%20pr%C3%A9sentaient,une%20eau%20de%20qualit%C3%A9%20insuffisante.

98/83/EG) [1]. Furthermore, also microbial indicator parameters, are checked, and need to be further examined in case there is an exceedance. These are: *Clostridium perfringens* (incl. spores), total bacterial counts at 22°C and 37°C and total number of colliform bacteria. These parameters are controlled by VMM (supervised by AZG) in Flanders (Reglementeringen inzake de kwaliteit en levering van water bestemd voor menselijke consumptie, also called: Drinkwaterbesluit, 13/12/2002), SPW in Wallonia (Code de l'Eau, articles D.180 à D.193, et articles R.252 à R.270), and VIVAQUA in Brussels. In the period of 2014-2016, the bacterial criteria were mostly reached in Wallonia. However, for certain distribution services in the provinces of Liège and Luxembourg, there appeared some exceedances in case of surface catchments, in times of flooding and due to lack of systematic disinfection of the water (environnement.wallonie.be, consulted in April 2021)[2]. In Flanders, the latest drink water quality report was of 2019. The regulators received 15 reports that the water supplied did not meet the quality requirements on a total of 9247 inspections. The calamities with the greatest impact were caused by a bacteriological contamination of the public water network. These bacteriological infections were a result of mismatched connections (no complete separation) in the indoor installation with other water such as rainwater/groundwater in combination with a malfunctioning non-return valve. This caused other water to enter into the public water network[3].

5.3.1.2 Food-borne diseases

There is a European regulation on microbiological criteria for inspection of specific food safety and food process hygiene (EU nr. 2073/2005). In Belgium the FPS Health, Food Safety and Environment is responsible for the risk management, while the Federal Agency for the Safety of the Food Chain (FASFC/AFSCA/FAVV) controls the enforcement. It includes amongst others control on *Listeria*, *Salmonella*, *Escherichia coli*, histamine[4], *Staphylococcus* enterotoxins, *Cronobacter spp*., aerobic total viable count, *Enterobacteriacea, Campylobacter spp., coagulase-positive staphylococci and Bacillus cereus*.

Furthermore, the European guideline 2003/99/EG Annex IV/E obliges the different member states of the EU to report data on food-borne infections to the European Agency of Food Safety (EFSA), as part of the yearly zoonoses report. EFSA and the European Centre for Disease Control (ECDC) made a document for harmonized reporting of food intoxication outbreaks in Europe. In 2004 a National Platform on Food Intoxications and by Food Transferred Zoonoses was established in Belgium. The main aims are exchange of detected outbreaks, epidemiological data, and reporting to EFSA[5]. Furthermore, the Federal Agency of Food Safety uses data on food intoxications in their Food Safety Barometer, a multiparameter indicator yearly calculated to compare the safety situation with the previous year. The results can be consulted online for the years 2008 - 2017[6]. In 2018 the concept of the barometer was reevaluated on a scientific basis, on the basis of the latest scientific evidence 22 food safety indicators were selected (FAVV, 2018a).

In 2019, there were 571 food intoxications in Belgium. This was the highest number since the registry started in Belgium (1999). In total 2457 individuals became ill, 28 were hospitalized. *Salmonella* was the most reported ill-making microbiological agents (216 individuals), followed by *Norovirus* (41 individuals), and other infections with *Clostridium perfringens*, *Listeria monocytogenes*, *Campylobacter*, *Bacillus cereus* and the pathogenic *Escherichia coli O157*. Biogenic amines such as histamine caused one outbreak in 2019. The sources of infection were diverse. Prepared contaminated foods were most often sent to the analytic lab (67.3%). The main place of outbreaks were restaurants (70.4% of outbreaks) (Sciensano, 2019).

[1] Bottled water is in addition also checked for *Pseudomonas aeruginosa*, and total bacterial load at 22 and 37°C.
[2] http://environnement.wallonie.be/ (Eaux > Qualité des eaux de distribution publique)
[3] https://publicaties.vlaanderen.be/view-file/39003
[4] Biogenic amine. Formed out of a free amino acids (present in nutrition) and Gram-positive and Gram-negative bacteria performing decarboxylation (of histidine to histamine), mainly due to food spoilage and in food stuff that undergoes bacterial processes (e.g. fermentation).
[5] https://www.sciensano.be/nl/biblio/voedselvergiftigingen-belgie-en-vlaanderen-jaaroverzicht-2019
[6] https://www.favv-afsca.be/wetenschappelijkcomite/barometer/voedselveiligheid/meten.asp

In the EU One Health Zoonoses report, published in 2021 by EFSA and ECDC, the results of zoonoses monitoring activities carried out in 2019 in 36 European countries, showed that campylobacteriosis, followed by salmonellosis, Shiga toxin-producing *E. coli* infections, yersiniosis and listeriosis were the main zoonotic food-borne diseases (EFSA/ECDC, 2021). Outbreaks were reported to be most occurring in 'domestic settings'. For some of the pathogens there were increases in outbreaks. They were explained by possibly being caused by changing eating and consumption habits (more delivered food/ take-away), an increasing older vulnerable population, and possibly climate change that may also play a part in increased exposure of food to contamination (EFSA/ECDC, 2021).

Sciensano assessed the disease burden of food- and water-borne diseases in Belgium for the period 2013-2020 (Sciensano, 2020, 2018). When considering both the morbidity and mortality impact of the concerned pathogens, and when correcting for underestimation, the highest population health impact was found to result from Norovirus infection, followed by campylobacteriosis and giardiasis. At the individual patient level, the highest burden was found to be caused by listeriosis and botulism. A time series analysis covering data from 2012-2020 from Belgium further showed that the burden of *Campylobacter* is increasing over time (Maertens de Noordhout et al., 2017).

In the light of climate change, mycotoxins in maize and cereals are also of importance. These naturally occurring toxins are important harmful food contaminants responsible for health effects such as cancer, nephrotoxicity, hepatotoxicity or immunosuppression. Assessment of mycotoxin exposure in the Belgian population using biomarkers showed a clear exposure to a broad segment of the Belgian population to certain mycotoxins (Heyndrickx et al., 2015).

5.3.2 Expected changes

5.3.2.1 General

ECDC reported already in 2012 that the main food- and water-borne diseases influenced by climate parameters are: (i) campylobacteriosis - an enteric[1] infection transmitted through contaminated food and drinking water – observed to be associated with mean weakly temperatures; (ii) *Cryptosporidium* spp. outbreaks and especially salmonellosis being associated with irregular and severe rains; (iii) non-cholera *Vibrio* spp. showing an increased growth in coastal waters during summer; (iv) *Norovirus* and *Listeria* spp. appeared to show a rather weak association with climatic variables (ECDC, 2012). In an ECDC report of 2010 a table was included with the main communicable food and water-borne diseases of concern, and whether they are impacted by climate-related changes, see *Table 5-7* (ECDC, 2010). The main infectious diseases mentioned to have a climate change related transmission route, and thus to be expected to increase in case of climate changes, are: botulism, campylobacteriosis, cholera, cryptosporidiosis, giardiasis, Verocytotoxin producing *Escherichia coli* (VTEC), Hepatitis A, possibly Listeriosis, Salmonellosis, Shigellosis, Typhoid/paratyphoid fever, and Yersiniosis.

Table 5-7. Infectious diseases: how climate change may impact transmission of main communicable food and water-borne diseases of concern (table taken from ECDC (2010)*) (indication whether the transmission is yes/no influenced by climate change related parameters).*

Disease	Yes	No	climate change-related transmission route
Botulism	x		Foodborne. Temperature linkage. Small risk, only if inadequate cold storage (vacuum-packed food). High water temperature (lakes, sea) that causes

[1] enteric pathogens are pathogens associated with human/animal faecal contamination. Reference pathogens are *Campylobacter* for enteric bacteria, *Norovirus* and *Adenovirus* for human enteric viruses and *Cryptosporidium* and *Giardia* for human enteric protozoan parasites.

Disease	Yes	No	climate change-related transmission route
			increased risk of *C. botulinum* type E in fish.
Brucellosis		x	
Campylobacteriosis	x		Linked to heavy rain
Cholera	x		Linked to heavy rain
Transmissible spongiform encephalopathies (TSE)		x	
Cryptosporidiosis	x		Linked to heavy rain
Echinococcosis		x	
Giardiasis	x		Linked to heavy rain
Verocytotoxin producing *Escherichia coli* (VTEC)	x		Linked to heavy rain
Hepatitis A	x		Linked to heavy rain
Listeriosis	[x]		Foodborne: Temperature linkage. Very small risk, only if inadequate cold storage and transport (as bacteria can grow at refrigerator temperatures)
Salmonellosis	x		Foodborne: Temperature linkage Waterborne: Linked to heavy rain
Shigellosis	x		Linked to heavy rain
Toxoplasmosis		x	Waterborne: Only one reported major outbreak (Canada): water source was contaminated by run-off with cat faecal matter from soil nearby
Trichinellids		x	
Typhoid/paratyphoid fever	x		Linked to heavy rain
Yersiniosis	x		Foodborne: Temperature linkage, but small risk only if inadequate cold storage. Waterborne: Linked to heavy rain

Within the PESETA II-project an integrated model for the health impacts of climate change has been developed (Paci, 2014). For the incidence of salmonellosis and campylobacteriosis exposure-response functions have been used based on a change in average weekly temperature above a certain threshold. The climate change attributable cases of salmonellosis and campylobacteriosis are projected to increase from 28,438 per year in 2010-2040, to 32,501 in 2041-2070, to 35,989 in 2071- 2100, numbers are for EU-total (Paci, 2014).

5.3.2.2 **Water-borne diseases**

Some water-borne diseases are expected to be impacted by climate change. In general, there is an increased concentration of bacterial contamination due to decreased water flow in summer (see sections 2.2 and 2.3) or increased water flow during floods (causing leakages of pathogens from soil or the animal sector), higher temperatures, oxygen depletion, or infrastructure damages due to extreme climate events (ECDC, 2010). Due to nutrient enrichment (eutrophication) and climate change, also harmful algal bloom (*Cyanobacteria and toxin-producing microalgae*) tend to increase in frequency, magnitude and duration worldwide. Nutrients, temperature, dissolved carbon dioxide, salinity and mixing regime are the most important associated drivers for it. Recently Pilla et al. (2020) published a paper on worldwide highly variable deep water temperature trends in lakes, which may be due to regional climate patterns or additional external anthropogenic influences. Those changes are described to cause potential changes in thermal habitat characteristics for a variety of organisms, alteration of nutrient cycling, stimulation of harmful algal blooms, deep-water oxygen depletion, and changes in greenhouse gas production.

In the report of 2010, ECDC stated furthermore that: “climate change may cause outbreaks of diseases transmitted in different ways through drinking or recreational waters. Adaptation measures, like increased use of cooling towers and air conditioning, may also create waterborne outbreaks through inhalation of contaminated air droplets and mists (e.g. legionellosis). Droughts may have negative effects on both water quantity and quality. Increases in temperature will cause increased growth of certain pathogens/parasites in water sources (including private drinking and recreational water sources) and in water pipe lines. The growth of bacteria, like *Vibrio parahaemolyticus, Vibrio vulnificus* and *Vibrio cholera* (non-O1 and non-O139), in the sea and brackish waters substantially increases at higher temperatures. Longer and hotter summers will also increase the risk of direct pathogen transmission as more people use recreational bathing sites. Heavy rain may cause leakages of zoonotic and environmental pathogens (such as *Campylobacter, Salmonella, Cryptosporidium*, and *Yersinia*) into drinking water sources and recreational waters. Flooding and landslides can damage infrastructure (water treatment plants, electrical substations, etc.), overload capacity or cause the leakage of sewage into water sources. Surveillance of food- and waterborne diseases has improved in the EU” (ECDC, 2010).

Already in 2013, the European Commission published a document on the climate change impacts on water systems (OECD, 2013). They stipulated that Western Europe is vulnerable to water scarcity, droughts, and floods. They stated that the largest unknown is about future water quality, which is expected to decrease resulting from diffuse source loadings released with floods and heavy rainfall or reduced dilution capacity of the rivers. Transboundary river basins are of particular interest, as they have to deal with many kinds of vulnerabilities.

5.3.2.3 **Food-borne diseases**

It is well known that climate change constitutes a relevant driver of emerging risks, potentially also impacting on food safety due to the (re)emergence of new hazards and an increased exposure and susceptibility to known hazards, resulting in an increase or change in the occurrence and intensity of certain foodborne diseases (FAO, 2020). EFSA, within the CLEFSA (CLimate change and Emerging risks for Food SAfety) project, made an assessment of possible issues related to biological hazards and impact to human health due to climatic changes (Maggiore et al., 2020). New risks are also possibly associated with the introduction of new crops, new cultivation methods, novel food and feed sources, etc.

Elevated temperatures accelerate the replication cycles of food-borne microorganisms, and extended summer seasons may increase the chance of mistakes in food handling. Extreme and erratic rain events can flush pathogens into water treatment and distribution systems, resulting in community outbreaks (ECDC, 2012b).

In the report of ECDC (2010) on Climate change and communicable diseases in the EU Member States, it was stated that: “Many foodborne pathogens will increase their growth rate at higher temperatures, although some pathogens, like *Listeria*, can start growing at refrigerator temperatures. Studies from the UK have shown linear relationships between ambient temperatures and outbreaks of *Salmonella* infection. As *Vibrio* concentrations tend to be higher at warmer water temperature, an increase in outbreaks and cases can be linked to increased sea surface temperatures and also heat waves. In general, the link between climate and foodborne outbreaks are probably most often due to improper production, storage, transport, handling and preparation of food at higher ambient temperatures. Heavy rainfall may cause irrigation water or agricultural products to become contaminated with pathogens from both soil and the animal sector.”

In a recent review increased levels of mycotoxins in cereals were observed due to climate change (Liu and Van der Fels-Klerx, 2021).

5.3.3 *Current and planned measures*

5.3.3.1 Data availability on food- and water-borne diseases

Food-borne diseases

As already mentioned above, detection of food infections and intoxications is well organized in Belgium. It includes preventive inspections in the food chain and registration of outbreaks. The Federal Agency for the Safety of the Food Chain (FASFC/AFSCA/FAVV) controls the enforcement of legislation, its scientific committee SciCom regularly updates limit values based on scientific research and recommendations of EFSA, this was recently performed for mycotoxins in cereals for food and feed(FAVV, 2018b).

The regional health authorities (AZG, AVIQ, COCOM) are responsible for managing the mandatory reporting of notifiable infectious diseases (e.g. Salmonella) and for investigating food-borne disease outbreaks. In case of food infections, data are transferred to the Federal Agency for the Safety of the Food Chain (FASFC/FAVV/AFSCA).

Sciensano coordinates the network of sentinel laboratories and the various National Reference Labs measure and collect incidences at the national level, e.g. the National Reference Labs for Foodborne Outbreaks, Foodstuff transmitted Zoonoses, the Reference Centres for *Salmonella* and *Shigella*, *Listeria, Clostridium botulinum* and for *Norovirus*, the Laboratory for Medical Microbiology, the National Reference Laboratory for mycotoxins. Furthermore the FASFC is performing research in the food chain, taking samples, and the medical inspectors examining patients and performing epidemiological research.

Water-borne diseases

Water quality for (drinking) water for human consumption and bathing water quality are also examined on yearly basis. The earlier mentioned regulated drinking water parameters are controlled by VMM (supervised by AZG) in Flanders (Reglementeringen inzake de kwaliteit en levering van water bestemd voor menselijke consumptie, also called: Drinkwaterbesluit, 13/12/2002), SPW in Wallonia (Code de l'Eau, articles D.180 à D.193, et articles R.252 à R.270), and Vivaqua in Brussels.

For bathing water, inspection during blooming periods is done by VMM in Flanders, SPW-Aqualim in Wallonia, and Environment.Brussels[1] in Brussels. In addition to sampling of water, sporadic monitoring for dead fish and birds is performed at recreational water sites, in addition to visual monitoring for trash/litter. To monitor for the presence of *Cyanobacteria* blooms, bathing waters are visited biweekly and inspected visually for the presence of *Cyanobacteria* layers and presence of *Cyanobacterial* flocs in water samples. VMM has an online reporting system for blooms of *Cyanobacteria*[2]. VMM translated the UK the "Bloomin' Algae" app[3] that enables users to send a photo of the bloom and details of its location. The app will be launched soon, VMM will perform a validation of the reported photos.
Within the ENVIeS-plan the use of remote sensing data for the detection of *Cyanobacteria* is currently explored (SPW Environnement-santé, 2019). The use of remote sensing as a starting point to plan a monitoring programme, for example, by identifying the season of cyanobacterial blooms or locating sites of biomass accumulation, was also mentioned in the latest guidance by WHO (WHO, 2021b).
The regional health authorities (AZG, AVIQ, COCOM) are responsible for managing the mandatory reporting of notifiable infectious water-borne diseases.

[1] https://environment.brussels/state-environment/report-2011-2014/water-and-aquatic-environment/biological-quality-main-waterways
[2] https://www.vmm.be/contact/blauwalgen-melden
[3] https://www.ceh.ac.uk/news-and-media/news/bloomin-algae-new-app-help-reduce-public-health-risks-harmful-algal-blooms

5.3.3.2 Information, sensibilization and prevention measures

Food-borne diseases

Considering sensibilization and education, WHO published five clear food safety keys (WHO, 2006). (1) Keep clean: washing of hands before touching of nutrition, and also during preparation of food, after each toilet visit, cleaning surfaces and food contact materials, keep bugs out of the kitchen. (2) Separate raw and cooked food and all materials used to prepare them; (3) Cook thoroughly: cooking or reheating of food (meat, chicken, eggs, fish), sauces should be done to a temperature of minimal 70°C in the centre of the food product; (4) Keep food at safe temperatures: store on a safe place i.e. no longer than 2 hours at room temperature, 5°C in refrigerator for cooked food, serve cooked food at minimal 60°C, defrost frozen food in refrigerator; (5) Use safe water and raw materials i.e. rinsed, fresh, safely pretreated.

They bring attention to the most important aspects of prevention i.e. keeping food free of contamination, which certainly apply in case food is handled, prepared and consumed in warmer climates. Over 130 countries worldwide, including Belgium, use these keys for safe food handling behaviors and education of food handlers, including consumers. Each year, WHO also organizes World Food Safety Day, on 7 June, to raise awareness about food safety.

Water-borne diseases

The Belspo B-BLOOMS2 project[1] provided advice to the authorities in identifying and refining policies and measures related to the risk assessment and management of cyanobacterial blooms. De Blauwe Cluster[2] started an initiative this year to prepare a recommendation in relation to marine and aquaculture in Belgium, following the resolution on the development of sustainable and integrated aqua and marine culture by the Flemish Parliament[3].

When layers of *Cyanobacteria* are observed (or reported by citizens or municipalities), the competent water authority closes the water for recreation and captation. Samples are taken to test for microcystin and cyano-chlorophyll. Recreation is prohibited until the concentration of microcystin drops below 20 µg/L and cyano-chlorophyll drops below 75 µg/L and visible blooms have dispersed. Captation is prohibited until the concentration of microcystin drops below 1 µg/L and visible blooms have dispersed. The water authority informs the recreants and farmers through warning signs at the water body of concern and by an emailing list.

For the health risks related to cyanobacteria, flyers have been developed by AZG for Flanders and by SPW-Environnement-Santé for Wallonia, these are available online[4].

The Bathing Water Quality Directive 2006/7/EC states that information should be made available for the public. For recreational waters maps are available with the quality of the swimming water, these maps are published by VMM and AZG for Flanders[5] and by SPW-Environnement[6] for Wallonia.

5.3.3.3 Information flow to medical practice

AZG has an interactive tool to display annual data starting from 1999[7]. In case of food-borne (and drinking water borne) diseases communication to healthcare personnel is performed through FASFC.

The information flow and communication channels on other infectious diseases are covered in section

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[1] https://www.bblooms.be/

[2] https://www.blauwecluster.be/

[3] https://docs.vlaamsparlement.be/pfile?id=1695628

[4]http://environnement.sante.wallonie.be/files/document%20pdf/D%C3%A9pliant%20sur%20les%20cyanobact%C3%A9ries.pdf; http://environnement.sante.wallonie.be/news/debut-de-la-saison-balneaire--attention-aux-cyanobacteries;https://www.zorg-en-gezondheid.be/sites/default/files/atoms/files/Folder%20blauwalgen%202020.pdf

[5] https://kwaliteitzwemwater.be/nl

[6] http://environnement.wallonie.be/baignade/#/station/map

[7] https://www.zorg-en-gezondheid.be/cijfers-over-meldingsplichtige-infectieziekten-0

6.1.3.1.

5.3.3.4 Control measures of cyanobacterial blooms

The most effective and sustainable control of cyanobacterial blooms in surface waters is obtained by reducing eutrophication in waterbodies by sufficiently limiting the nutrient loads that it receives (WHO, 2021b). The major sources of nutrients are agricultural run-off and untreated wastewater. The run-off is intensified by intense precipitation and flooding. Another possibility is the removal of the nutrient-rich sludge from the bottom of the waterbody. BE/LB is currently investigating the possibilities of chemical sequestration of phosphorous on the bottom of the waterbody within the PHOS-LOCK/PHOS-SINK project. Within the Interreg project NuReDrain[1] VMM conducted a first pilot project to remove phosphorus and nitrogen efficiently from agricultural waters such as surface water[2]. Other practices to mediate cyanobacteria blooms include removal of water in smaller waterbodies during winter to eliminate germination sites for cyanobacteria, chemical alternative to treat blooms (e.g. herbicides, hydrogen peroxide), aeration of waterbodies to increase movement, water level changes, adjustments of the fish stock, etc. (WHO, 2021b).

Data obtained by Sciensano shows that blooms can accumulate high concentrations of microcystin in ponds, lakes and canals (not yet published), as was earlier observed in the B-BLOOMS2 project.

Within the ENVIeS-plan there is an action aiming to strengthen the prevention of surface and groundwater contamination (SPW Environnement-santé, 2019).

5.3.3.5 Circular use of water - health risks

One of the five strategies of the Flemish Adaptation Plan 2021-2030 concerns circular economy, one of the aspects is the reuse of water. The Flemish Government's vision paper "Visie 2050 - Een langetermijnstrategie voor Vlaanderen"[3] puts a robust water system first. As the current legislation does not suit a circular economy (e.g. the reuse of water within or between companies is not permitted) steps will be taken to adapt legislation to make it more compatible with the needs of a circular economy. This needs to be done in collaboration with the federal government and European legislation. Recent European regulation on the reuse of wastewater in agriculture[4], deals with the irrigation of agricultural land, EFSA made a review and analysis of occurrence, exposure and toxicity of cyanobacteria toxins in food (EFSA, 2016). Literature suggests that toxin accumulation in plants through contaminated irrigation water is a potential health risk (EFSA, 2016). In the Targeted Research (RT) project CYANTIR, funded by FPS-Health, the food safety risks associated with the use of surface water contaminated with cyanotoxins for crop irrigation is being studied. It will assess the potential accumulation under the assumption that more bloom-prone waterbodies will have to be used in the future as a source for irrigation due to increasing drought periods during summer as a result of climate change.

5.3.4 Gaps between risks and current/planned measures - Adaptation actions and recommendations

5.3.4.1 Data availability - underreporting of food- and water-borne incidences

In the surveillance of incidents of food- and water-borne infection there is in general a systematic underestimation in the numbers: not all frequently occurring pathogens can be monitored, and most people do not seek medical attention for gastroenteritis symptoms (ECDC, 2010).

There is also the challenge of under investigated agents: when a foodborne outbreak is under investigation, often a causative agent cannot be found, which is reported as 'agents unknown'. A

[1] https://northsearegion.eu/nuredrain/
[2] https://www.vmm.be/nieuwsbrief/februari-2021/efficienter-fosfor-verwijderen-op-rwzi2019s
[3] https://publicaties.vlaanderen.be/view-file/19586
[4] https://emis.vito.be/sites/emis/files/legislation/91/2020/pbl050620-2.pdf

possible reason for this is that only a limited number of microbial parameters is investigated with the risk of missing out on the actual cause. Something that might become a bigger issue towards the future is there would be an increase in foodborne outbreaks due to these under investigated agents. An alert system based on the monitoring of the number of foodborne outbreaks of unknown causative agents could identify a possible trend in an early stage. This alert would dictate further investigation (retrospective or future oriented monitoring). To facilitate data collection and information gathering, citizens can be encouraged to report their symptoms via an app or social media channels. A similar reporting system could be set up for estimation of the incidence of water-borne diseases.

For foodborne disease outbreaks, there is a selection of large outbreaks, restaurant-related outbreaks or related to social events. The reporting depends on the number of people getting ill, the severity of the disease, possible hospitalization, and incubation time. In case there is a short incubation time, then outbreaks are more easily reported. This, of course mostly also holds for water-borne diseases, and is therefore a point of attention.

For sporadic foodborne infections, which are being registered and reported through the Sciensano network of sentinel laboratories, underestimation originates from under-ascertainment and the non-exhaustiveness of the sentinel network.

For surveillance of complaints with respect to water quality for bathing, the Netherlands has developed a questionnaire system, the Bathing Water Survey[1]. The Dutch National Institute of Public Health and the Environment (RIVM) sends a (digital) questionnaire at the end of the bathing season requesting local health departments and provinces to enter the bathing water related health complaints they have received/noted. That information is compiled into an annual surveillance overview. Health complaints may also be more overtly communicated to stakeholders such as province, council, households, owners of bathing places or food handling and cooking personnel.

5.3.4.2 **Prevention for food-borne disease**

A good operational plan for food control is in place in Belgium, this involves the production, distribution and selling aspects of the food chain as well as preparation of food in a professional context. The handling of food in households is not controlled, sensibilization and education based on the above-mentioned food safety keys from WHO can be considered. An estimate on climate-change related causes of food outbreaks, could be a good way to raise awareness for the topic in all stakeholders.

The share of food supplements in the consumer health market has grown. This growth implies an increased exposure of the public to these products and their ingredients. Some ingredients, mainly from natural sources, might exert adverse effects due to the presence of non-intentional compounds, like natural toxins. Food supplements produced by microalgae or cyanobacteria are currently under investigation (Van Hassel et al., 2020).

5.3.4.3 Information flow to medical practice

As for the vector-borne diseases it is a concern that there are not enough communication flows between government levels and the healthcare sector. Several interviewees have the perception that healthcare workers do not receive all newest information on the occurrence and spreading of disease cases identified nationwide and beyond (Anonymous, 2021a).

5.3.4.4 **Adjustment of regulation for waterborne diseases**

Where needed, regulations need to be adjusted to control the introduction and spread of (climate change related) waterborne diseases in public drinking water sources, and spread of foodborne diseases during food production, processing, transport and storage (ECDC, 2010).

The quality of water deteriorates during dry periods of low river discharge. This is because the effect of spills from sewage water treatment plants is much larger due to less dilution of polluting substances. In the Netherlands a system is in place that limits some sewage water discharges into surface water in

[1] https://www.rivm.nl/zwemwater/zwemwaterenqu-te

case of very dry or wet periods (RIVM, 2013). As mentioned in section 5.3.3, the ENVIeS-plan aims to strengthen the prevention of surface and groundwater contamination (SPW Environnement-santé, 2019).

Intoxication cases contributed to the development safety guidelines for some of Cyanobacterial toxins. For Microcystin (in particular MC-LR), WHO suggested tolerable daily intake (TDI) of 0.04 µg $kg_{bodyweight}^{-1}$ day^{-1}. They further translated this value to a reporting limit of 1µg/L for chronic exposure and 12 µg/L for short term exposure in drinking water and 24 µg/L for water used for recreation. These values were recently updated(WHO, 2021b). Earlier published value for drink water (1 µg/l independent of exposure time) from WHO was adopted in the new EU water directive. The previous guideline value for recreational waters (20 µg/L) is utilized by the VMM. However, there is a lack of toxicological data (for variety of Cyanobacterial toxins) to evaluate complete risk for public health. New guidelines were also presented by the WHO for other cyanotoxins (e.g. cylindrospermopsin, saxitoxin and anatoxin-a), an overview is given in Table 5-8 (WHO, 2021b).

Table 5-8. New guidelines for various cyanotoxins. Source: WHO (2021b).

Toxin	Drinking water		Recreational water
	Short term (µg/L)	Chronic (µg/L)	Short term (µg/L)
Microcystin	12	1	24
Cylindrospermopsin	3	0.7	6
Saxitoxin	3	/	30
Anatoxin-A	30	/	60

5.3.4.5 Adaptation of surveillance programs for waterborne disease outbreaks

ECDC (2010) advises the installation of an early warning systems, and quick operational labs for examination of sources of waterborne disease outbreaks. A good example to implement this is formulated in the report 'Monitoring pathogens in recreational bathing waters in Flanders' (KWR, 2019). It was stated that adjustment of proactive and reactive monitoring could be part of adaptive measures. The current **proactive** monitoring for *E. coli* and *enterococci* protects bathers against bathing waterborne infections by enteric bacterial pathogens, such as *Campylobacter, Salmonella, Shigella, E. coli*. However, it is less suited to protect bathers against infections with viral and protozoan parasites that persist longer in water. It was recommended to perform research to determine the added value of monitoring coliphages (these are viruses that infect bacteria and are adequate surrogates for human enteric viruses(KWR, 2019).

For *cyanobacteria* (blue algae) the tiered approach used in the Netherlands was advised. It could be evaluated whether the current (cyano chlorophyll and) microcystin analysis can be complemented with another toxins, such as cylindrospermopsin (as recently introduced by the US EPA). It was also recommended to evaluate which guideline for microcystin (8 µg/L (US EPA) or 24 mg/L (WHO) instead of 20µg/L) is most appropriate in protecting the health of the bathers. Considering **reactive monitoring**, i.e. monitoring that is triggered by notification of a potential problem (such as large numbers of dead birds or fish) or (a cluster of) health complaints via bathing water. The current system of disease surveillance can be used. Ideally, notification of a (cluster of) health complaints is to be followed by investigation and evaluation and monitoring of the presence of the specific pathogens. Since outbreaks of diseases through bathing water always require rapid action, it is recommended to have a list with contact details of the laboratories that are experienced in water monitoring for the different pathogens/toxins (KWR, 2019).

Modeling of environmental factors contributing to cyanobacteria bloom development, species and toxin composition would provide insight in possible mitigation strategies for blooms in the future. The new EU water directive and WHO both suggest a waterbody specific, holistic, risk assessment and risk management approach to mitigate water quality problems, like cyanobacteria bloom, in catchment areas. This approach could also potentially be applied to recreational areas. Bloom models could provide an important piece in the risk management puzzle (WHO, 2021b). Public awareness and citizen science initiatives can contribute to risk mitigation by mapping bloom prevalence in Belgium and informing the general public about the dangers of harmful algal blooms.

5.3.4.6 Health risks associated to circular use of water

As mentioned in section 5.3.3.5 reuse of water is promoted but might involve health effects. The EU regulation focuses on the irrigation of agricultural land, however initiatives are being taken that are not limited to the reuse of water for the irrigation of agricultural land, but also include other applications. Sometimes it concerns higher-grade applications (e.g. reuse as drinking water or in the food industry). Therefore, the question arises whether and how a broader (legal) framework can be provided in the regions for water reuse. In the past, there was the reuse of treated effluent from wastewater treating plants for the spraying of agricultural land. In response to droughts, Aquafin[1] made purified effluent available to farmers and municipalities. In Wallonia, experiments in wastewater reuse also exist, on an ad hoc basis. Some municipalities use water from wastewater treatment plants for watering their green spaces[2]. In Wallonia, water is not yet recovered for field irrigation and there is no office for the recovery of company water. However the Société Publique de la Gestion de l'Eau (SPGE)[3] is currently looking into this[4]. Caution is advised when spraying such water, which may have a microbiological load, among other things and might cause e.g. legionellosis. All human contact (directly or indirectly via fogging, sprinkling or the use of sprayed areas) should be avoided. This applies to the user, other personnel, site users, residents and passers-by. The water should be used as soon as possible after collection. Stagnation and heating of the water causes a further deterioration of the water quality (e.g. germ growth). This increases the risks associated with its use.

5.3.4.7 **Spatial planning considerations**

The installation of green and blue infrastructures, especially in urban environments, allows people to come into contact with water in public spaces more often and in a different way. Apart from the benefits (see sections 5.1.3.4, 5.5.3.2 and 7.2.3), contact with water can also cause health problems. It is therefore important to consider the quality of water when designing, planning and implementing urban water initiatives. In the Netherlands the water quality checklist for new and existing urban water concepts can be used for carrying out a risk analysis (RIVM, 2017). If this checklist can be made more quantitative, it will allow the potential health risks of sustainable water initiatives to be carefully identified and, if necessary, adjustments to be made to reduce the health risks identified.

The ongoing study by the Flemish Department of Environment (see section 5.1.3.4) will address these issues.

[1] https://www.aquafin.be/nl-be
[2] https://www.rtbf.be/info/belgique/detail_recycler-les-eaux-usees-pour-irriguer-les-champs-une-pratique-qui-reste-timide-en-belgique?id=10582013
[3] http://www.spge.be/nl/index.html?IDC=1
[4] https://www.rtbf.be/info/belgique/detail_recycler-les-eaux-usees-pour-irriguer-les-champs-une-pratique-qui-reste-timide-en-belgique?id=10582013

5.4 POLLEN & SPORES, ALLERGIES AND RESPIRATORY DISEASES

Climate change is considered to be the largest health threat of the 21st century worldwide (Costello et al., 2009). One of the consequences of climatological changes is a change in exposure to allergenic bioaerosols, and as a consequence an increase in respiratory diseases including allergic rhinitis (hay fever) and asthma. Increasing evidence shows that climate change has already affected and will further affect pollen-carrying and allergenic plants, and as a consequence allergic diseases (Beggs, 2015; Confalonieri et al., 2007). Higher temperatures but also elevated atmospheric CO_2 concentrations have implications for seasonal distribution (timing and duration), concentration, allergenicity and geographical distribution of allergenic species and aeroallergens (Anderegg et al., 2021; D'Amato et al., 2020; Ziska et al., 2019a). This is expected to aggravate associated diseases, including acute and chronic allergic reactions and severe asthma (Beggs, 2015; Smith et al., 2014). Interactions with other dynamics, including projected altered humidity and rainfall patterns, more extreme weather events, high ozone concentration and air pollution may further directly and/or indirectly worsen allergic reactions. The BELSPO-funded project RETROPOLLEN (2020-2023) aims at assessing the public health effects of birch and grass airborne pollen levels in relation to surface air pollution and climate change using up to four decades of historical observations. As well, a new BELSPO-funded project, NITROPOL-BE, currently investigates the effects of environmental nitrogen pollution and air pollution on the allergenicity of grass and tree pollen.

Since a growing fraction of the Belgian population already suffers from allergic diseases and respiratory allergic diseases are to become more prevalent, a high share of our population is at risk of severe allergic diseases. As reported in the last national health survey of Sciensano, allergies appear to be ranked among the five most prevalent chronic affections and diseases in the Belgian adult population (Van der Heyden and Charafeddine, 2019). Moreover, the successive editions of this survey confirm that this prevalence has been increasing these last decades, especially in the recent years, for both men and women.

5.4.1 Current situation

5.4.1.1 Pollen and allergic diseases

In Europe, grasses (Poaceae family) are the major cause of allergic reactions due to pollen, for which the main flowering period happens between May and July in Belgium. According to Blomme et al. (2013), about 18% of the Belgian population might be estimated to be allergic to grass pollen. For tree pollen, birch (*Betula* spp.) is a most allergenic with a strong health impact. In Belgium, 10% of the population might be allergic to pollen of the Betulaceae family (including birch, hazel and alder) (Blomme et al., 2013). The flowering period usually runs from January to February for hazel and alder, and from March to April for birch. The start of the seasons for these trees is highly dependent on meteorological parameters, in particular temperature accumulation, during the period of the flower development (pre-season). The season duration is dependent on the yearly variable pollen production (especially for trees) but also on the meteorological conditions during the pollen dispersal period (optimal if dry and warm). The duration can vary from 2 to 8 weeks. Two recent studies in a cohort of Belgian tree pollen allergy patients demonstrated that residential exposure and dynamic exposure to green space reduce mental distress, and have mixed effects on the severity of pollen allergy symptoms (Aerts et al., 2020c; Stas et al., 2021). Exposure to residential green space was associated with more severe allergy symptoms, whereas dynamic exposure to green space was associated with less severe allergy symptoms. The perceived presence and the amount of allergenic tree species, in particular birch, in forests within 2 km of the residence contribute to mental distress.

In the European Union, estimates count 44 to 76 million people (about 20-30 % of the population) suffering from an **allergic disease** (Wolf et al., 2015; Zuberbier et al., 2014). Pollen-related allergic diseases account for about 10-20 % of all allergic diseases (Bresser et al., 2005). In Belgium, the prevalence of allergic rhinitis against pollen is estimated to be around 20 % of the population (Blomme et al., 2013). Allergic diseases are an important cause of decreased quality of life, productivity loss, healthcare costs and morbidity. The great majority of patients (90%) is thought to be un- or maltreated for their allergy (Wolf et al., 2015). In the past decades, the prevalence of pollen-induced allergies has increased in Europe (D'Amato et al., 2007).

Zuberbier (2014) quantified the avoidable annual indirect cost of patients insufficiently treated for allergy to range between €55 and €151 billion due to absenteeism and reduced productivity at work in the European Union. In addition, allergies also affect kids' performance at school, for which assessing costs is more difficult. On the other hand, appropriate therapy for allergic diseases is available at comparatively low costs at an average of €125 per patient annually, which is only 5% of the costs of untreated disease (Zuberbier et al., 2014).

A recent study by Damialis et al. (2021a) tested the correlation between Covid-19 infection rates and pollen concentrations during the first pandemic wave in spring 2020, while accounting for confounding factors like humidity, temperature, population density and lockdown measures. Based on data of 130 sites in 31 countries (including Belgium), it was found that pollen concentrations could explain on average 44% of the infection rate variability with higher rates at higher pollen concentrations. Based on previous work, the authors hypothesized that pollen exposure causing inflammation of mucosal membranes opens gateways for respiratory infections, even in non-allergic persons. Wide dissemination of pollen-virus co-exposure risks of different infectious agents, including SARS-CoV-2, is important to reduce risks of increased infection in allergic patients. Mouth-nose masks are highly recommended by the authors for any patients at risk of respiratory diseases during episodes of high pollen concentrations to protect against pollen as well as Covid (Damialis et al., 2021). More generally, such kind of investigation highlights the needs to monitor the widest spectrum of environmental exposure that may affect both allergic and non-allergic population (exposome), and by taking into account the seasonal patterns of all these signals which may be affected by climate.

5.4.1.2 Respiratory diseases and asthma

Outdoor and indoor air pollution have an effect on respiratory health. Epidemiological research attributes the most severe respiratory health effects of air pollution to exposure to particulate matter and ozone. Besides asthma, rhinosinusitis, chronic obstructive pulmonary disease (COPD) and respiratory tract infections are the main diseases of concern.

Concerning respiratory morbidity and mortality due to short term as well as long term exposure to particulate matter, recent reviews shows that these effects persist until very low concentrations (Chen and Hoek, 2020; Orellano et al., 2020). The results from these studies will be used in order to update the WHO guidelines on air pollution (expected September 2021). The main cause of the respiratory health effects comes from combustion-derived particles that incorporate organic and transition metal components. Exposure to high ozone concentrations can cause acute respiratory problems due to inflammatory reactions in the airways (Zheng et al., 2021). The effects of ozone are very person dependent, people with chronic respiratory diseases are at the largest risk due to the reduced lung function, together with children and elderly people. But also healthy people engaged in prolonged outdoor physical activity in working or leisure conditions, may be extremely sensitive to ozone as their higher breathing rates leads to higher exposure.

There is also a relation between respiratory diseases and pollen exposure. A study of medication sales for obstructive airway disease in Belgium reports that living in close proximity to areas with high grass cover (grasslands, but also residential gardens) may negatively impact child respiratory health (Aerts et al., 2020a). Another study performed in the Brussels region showed a significant increase in asthma hospitalizations for an interquartile range increase in concentration of several allergenic pollen types, e.g. grasses and birch, and in synergy with air pollution (Guilbert et al., 2018). This suggests an association between severe asthma exacerbation and the chemical and biological air quality.

5.4.2 Expected changes

5.4.2.1 Pollen: seasonal shifts and prolongation of season

The onset and duration of pollen seasons are associated with meteorological variables, including temperature but also radiation, precipitation and humidity. The birch pollen season onset in Europe for example correlates with the cumulative temperature above a threshold of 3.5°C after 1 March (Siljamo et al., 2013; Sofiev et al., 2013). In response to global warming, plants shift the timing of their developmental stages, including flowering. A comprehensive study of global pollen datasets highlighted increases in pollen season duration and pollen load over time (Ziska et al., 2019a). This change was associated with anthropogenic climate change and rising temperatures (Anderegg et al., 2021). The onset of the typical spring pollen season has already been advanced in the whole northern hemisphere by several days to weeks in the past decades (D'Amato et al., 2014; Ziska et al., 2019b) . In the Netherlands, the start of the pollen season has advanced by 3 days to 3 weeks between 1969 and 2000 and similar shifts are to be expected in the future (Van Vliet et al., 2002). Figure 5-16 shows the interannual variation of the birch season onset in Belgium (and around) related to the temperature sum after 1 March. Notwithstanding the interannual variation, a trend towards earlier birch pollen onset dates of about 23 days, associated to higher temperatures, has been observed in Belgium between 1982 and 2000 (Emberlin et al., 2002). Also the pollen measurements performed by Sciensano show a clear trend towards an earlier concentration peak of birch pollen is visible: the peak advanced by more than one week in the period 1995-2018 as compared to the mean onset of 21 April in the period 1975-1985 (Figure 2). Similarly, the data show an earlier concentration peak for grass pollen: the peak advanced by more than one week in the period 1997-2018 as compare to a mean onset of 7 June in the period 1975-1995 (Vriens et al., 2019). With global warming, further advancement is expected. In 2020 the pollen season for alder and hazel started on early January in Belgium, which is two weeks earlier than usual and can be attributed to mild temperatures in the preceding months. In 2021, the unusually high temperatures in late February coincided with exceptionally high concentration peak of these tree pollen[1]. Higher temperatures in urban than in rural areas will lead to earlier pollen season onset in cities (D'Amato et al., 2014). While pollen concentrations are affected by several other factors besides onset (including pollen release and seed transport (dispersion)), the change in pollen seasonality (onset and duration) alters and extends human exposure to aeroallergens as well as the timing, duration and severity of allergenic diseases, which has implications for treatment timing (Confalonieri et al., 2007; D'Amato et al., 2007; Smith et al., 2014).

[1] https://airallergy.sciensano.be/nl/content/brussel

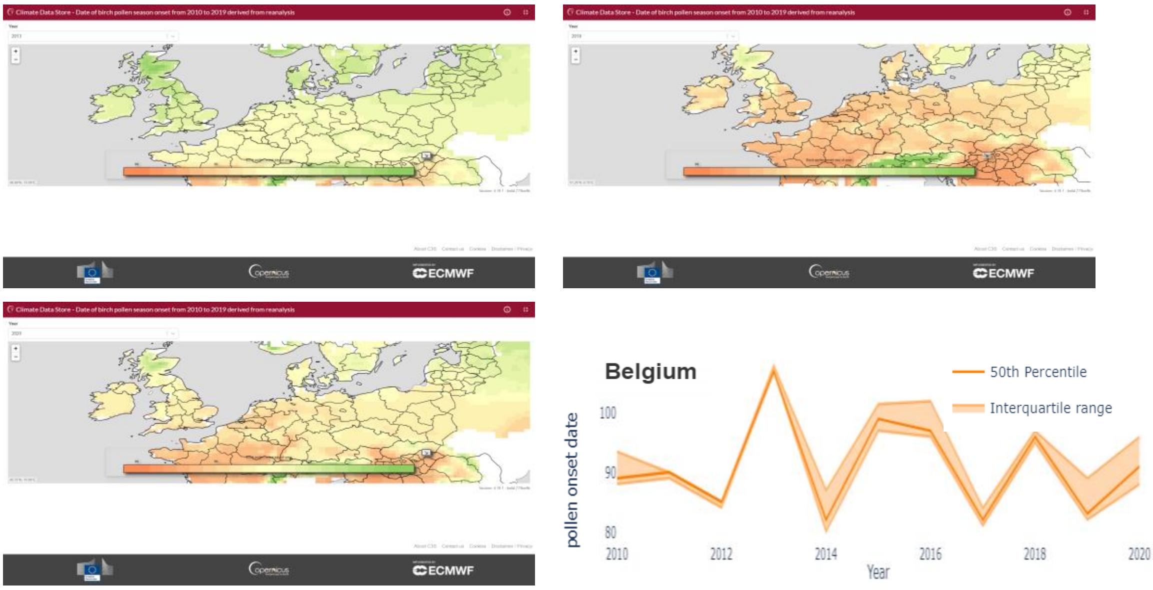

Figure 5-16. Yearly variation in onset (day of the year) of the birch pollen season based on ERA5 reanalysis data. Maps highlight onset over Europe in 2013, 2019 and 2020 (orange colours indicating earlier onset that green colours) and the graph shows the interannual variation in average onset (+ interquartile range) for the Belgian territory. Source: Copernicus Climate Data Store[1].

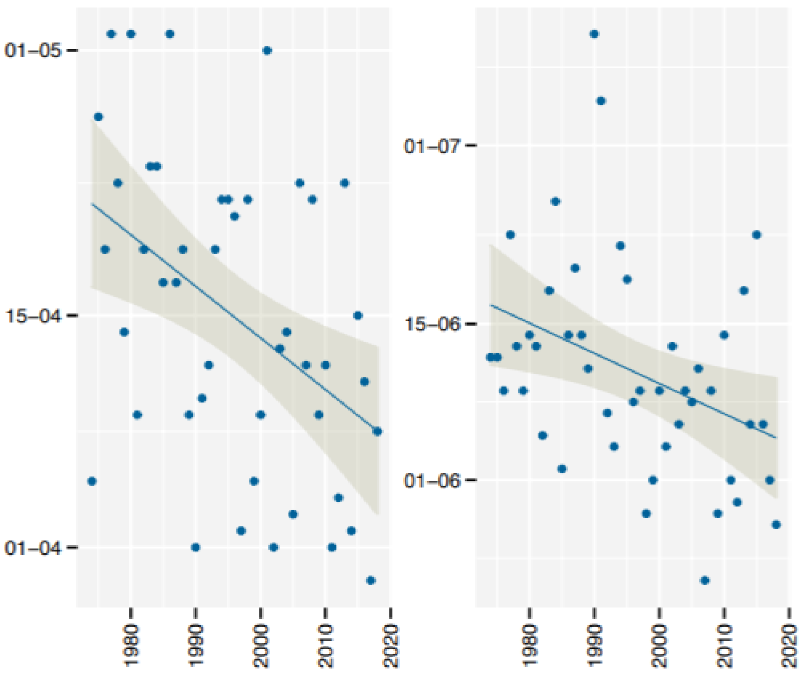

Figure 5-17. Trend in the annual pollen peak of birch (left) and grass (right). The vertical axis shows the date within a given year, the blue line shows the trend and the grey area represents uncertainty on this trend. Source: Vriens et al. (2019) *based on data of Sciensano.*

[1]https://cds.climate.copernicus.eu/cdsapp#!/software/app-health-birch-pollen-season-onset-current-climate?tab=overview

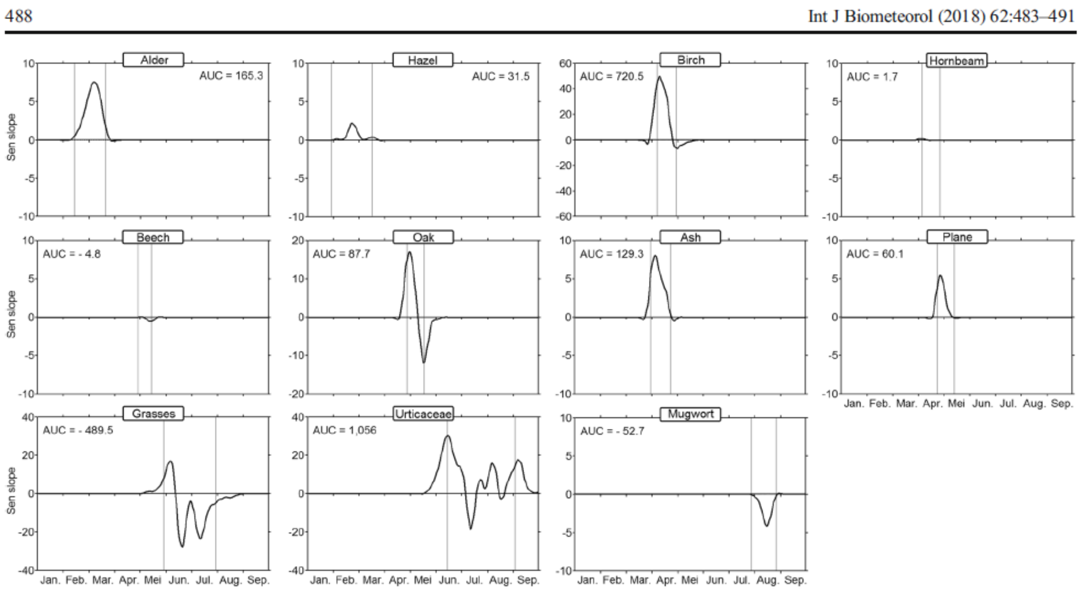

Figure 5-18. Time-series (1982 – 2015) of rates of change in the annual cycles of pollen concentrations for different plants (trees and herbaceous species) in Brussels. Source: Bruffaerts et al. (2018).

Bruffaerts et al. (2018) performed analyses of weather conditions and pollen concentrations in Brussels and found long-term shifts in absolute pollen concentrations and earlier pollen onset for birch, oak, ash, plane, hornbeam, grasses, and Urticaceae between 1982 and 2015. They also detected shifts in the **length and peaks of the pollen period**, although this change is much less univocal than the observed trends towards earlier onsets. Oak pollen concentrations for example have been tending to increase at the pollen season start and to decrease at the season end. As such the oak pollen season tends to overlap with the birch season. In contrast, beech pollen have been showing a trend of decreased concentrations in May (Bruffaerts et al., 2018).

5.4.2.2 Pollen: concentration and allergenicity

Warmer conditions as well as elevated atmospheric CO_2 concentrations stimulate plant growth and can increase the pollen load in the air as well as the allergenicity, which increases the risk for allergic reactions (Beggs, 2015; Smith et al., 2014; Ziello et al., 2012; Ziska et al., 2019). Long-term high NO_2 levels in urban environments have been associated with increased allergenicity of pollen of a number of species including birch (Gilles et al., 2018; Plaza et al., 2020). In Belgium, no studies related to the allergenic properties of pollen (specific allergen potency) had been conducted until the newly launched Belspo project NITROPOL-BE (2021-2024) which aims to evaluate the environmental factors that may influence these properties. Besides, the long-term observation of allergenic pollen levels in Belgium have shown a clear trend of increase in seasonal intensity since the start of the measurements in 1982. In particular, pollen emitted by birch, alder, hazel, plane and ash have been overall increasing despite their usual interannual variability (Hoebeke et al., 2018; Verstraeten et al., 2021). This trend of increase has been associated with the trend of increase of several meteorological parameters like temperature and radiation (Bruffaerts et al., 2018).

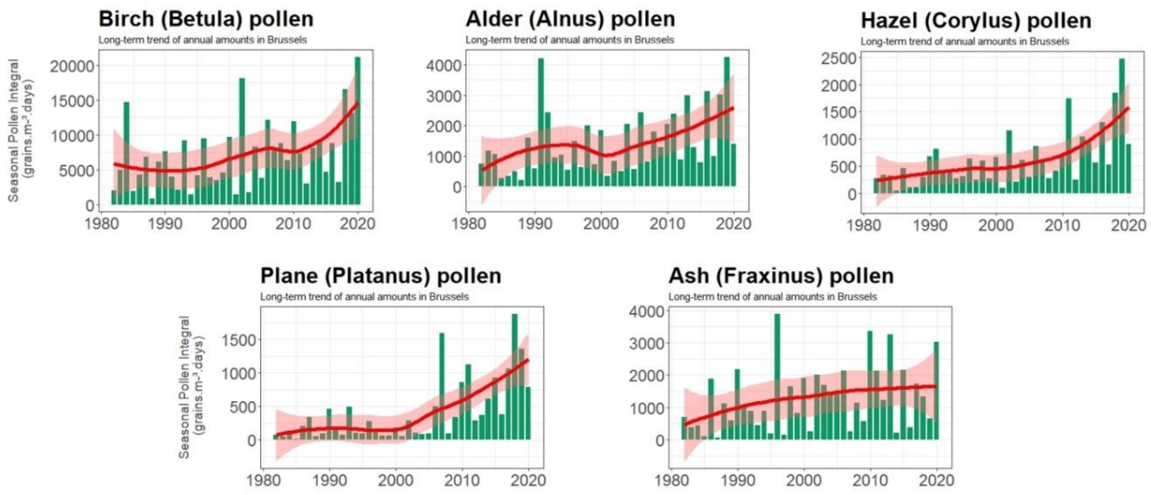

Figure 5-19. Long-term trend of annual pollen amounts measured in Brussels. Source: Sciensano.

High concentrations of pollen in the air have been associated with emergency calls for asthma with children (Wolf et al., 2015). Also altered humidity conditions, weather extremes and thunderstorms during the pollen season cause higher pollen loads in the air, which have been related to more severe allergic reactions and asthma attacks to pollen releases (D'Amato et al., 2020; Shea et al., 2008; Wolf et al., 2015). Adaptation measures to climate change, like green infrastructure in cities, may also increase the pollen loads and allergic reactions in cities in the future (Cheng and Berry, 2013). A case-study in 18 green spaces in Brussels demonstrates that the allergenic potential of urban parks is expected to double as a result of combined changes in the duration of the pollen seasons, the allergenicity of pollen, and the sensitization rates of the population. Removal of Betulaceae from parks would have little impact on the allergenic potential of such urban parks (Aerts et al., 2021).

5.4.2.3 Pollen: geographical shifts

Global warming and the concomitant increase in growing season length also facilitate the northward migration, introduction in new areas and spread of invasive plant species, which may include also species with allergenic pollen. The introduction of new allergens can increase local sensitisation (Confalonieri et al., 2007). Ragweed (*Ambrosia artemisiifolia*) requires special attention as a potential extremely allergy-inducing invasive species in Europe. It was introduced some decades ago from the American continent to Europe by human transport. The species may include an important health risk also in Belgium as the pollen are highly allergenic and spread relatively late in the season (early September), potentially causing an additional wave of allergy (Chen et al., 2018; Vogl et al., 2008). Significant health and economic impacts in invaded areas in Central and East Europe, France and Italy have been reported (e.g. Makra et al., 2005). Ragweed spread in Europe is mainly driven by human transport and agriculture activities. This herbaceous plant has a high pollen production capacity and pollen allergenicity. In North America, where ragweed is native, major allergic diseases have been associated to exposure to ragweed pollen since long and ragweed is a major cause of hay fever and asthma (Chen et al., 2018). Although its current invasion front in Western Europe covers mostly central and southern France and northern Italy, studies have shown that the species would perfectly be able to establish populations and become invasive in Belgium too in the near and far future (Lake et al., 2017; Ortmans et al., 2017; Storkey et al., 2014). Moreover, ragweed pollen grains can be transported hundreds to thousands of kilometres by air and cause peak pollen counts and associated allergy symptoms in areas where ragweed is not yet widespread (Chen et al., 2018). Figure 2 visualizes the modelled percentage of population sensitized to ragweed pollen in a reference and future period (Lake et al., 2017). Based on the simulation by Lake et al. (2017), ragweed sensitization in Belgium would increase by 2050 by 75 to 200%, as compared to the reference period assuming a moderate future greenhouse gas emission scenario (i.e. Representative Concentration Pathway (RCP) 4.5) and considering two different suites of climate/pollen models.

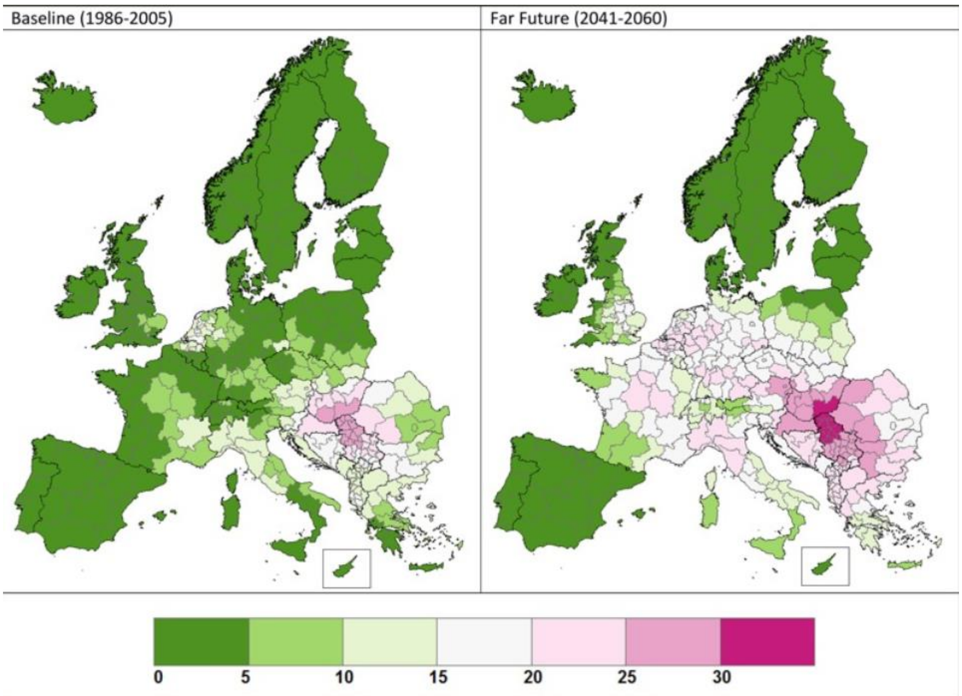

Figure 5-20. Modelled percentage of population sensitized to ragweed pollen at the baseline and future period assuming RCP 4.5. Source: Lake et al. (2017).

Next to pollen, climate change may also have a negative impact on diseases caused by other aeroallergens like moulds or allergens originating from insect, mite, fish and animal populations. Extreme events and wetter conditions can for example favour the in- and outdoor growth of molds and increase the prevalence of related diseases (D'Amato et al., 2020).

5.4.2.4 Spores

In particular, the fungus *Cryptostroma corticale*, responsible of the maple bark stripper's disease, is known to cause health risks to humans such as lung disease, i.e. hypersensitivity pneumonitis in people which are highly exposed to its allergenic fungal spores (occupational disease for lumberjacks, etc.). This tree disease owes its name to the black spore layer which emerges when the bark of infected trees has burst open. In 2016, the Flemish Research Institute for Nature and Forest (INBO) received the first report from Flanders of mortality of common maples due to maple bark disease (INBO, 2021). It was the first time that this fungus was identified in Flanders as a parasite on living trees. More observations from all Flemish provinces have followed nowadays. However, before 2016, this fungus was already observed on stacked firewood, so it would have been present in our country for a longer time. This fungus is currently reported from at least 10 European countries, but the exact distribution in Europe remains unclear. The occurrence of sooty bark disease is linked to extreme drought and heat, so it is no coincidence that it comes to the fore after the very dry, hot summers of recent years. It is also probably no coincidence that many sightings occur in urban environments, where the average temperature is higher than in the surrounding countryside. Climate change could lead to a further increase in this tree disease in Belgium.

5.4.2.5 Allergic diseases and asthma

The described effects of climate change on pollen are expected to lead to increased exposure of the Belgian population to pollen and aeroallergens in the future. This will increase the likelihood to develop new allergic sensitisations, increase allergic respiratory diseases in sensitized individuals and aggravate allergic symptoms and asthma in existing patients. Also people's susceptibility to viral infections through exacerbating respiratory inflammation and weakening immune responses may increase (Gilles et al., 2020). Moreover, the pressure from the Belgian allergic population to be informed about the measurement results was particularly strong in 2020, as shown by the amount of viewers on the AirAllergy website of Sciensano (see Figure 5-21). Indeed, this season was exceptionally abundant in pollen for many taxa but annual fluctuations in pollen production are not enough to explain this huge increase in the online sessions in 2020. The distinction between Covid-19 and pollinosis symptoms, which was initially not straightforward, might have exacerbated the public concern. Consequently, this synergy added to the pressure of the already saturated primary healthcare network during the first wave of Covid-19. In any case, this observation reveals that the convergence of the pollen season with the Covid-19 epidemic has dramatically increased the interest of the allergic population, as it should undoubtedly increase the interest of the scientific community given that many interconnected aspects remain to be explored between these two factors of respiratory comorbidity.

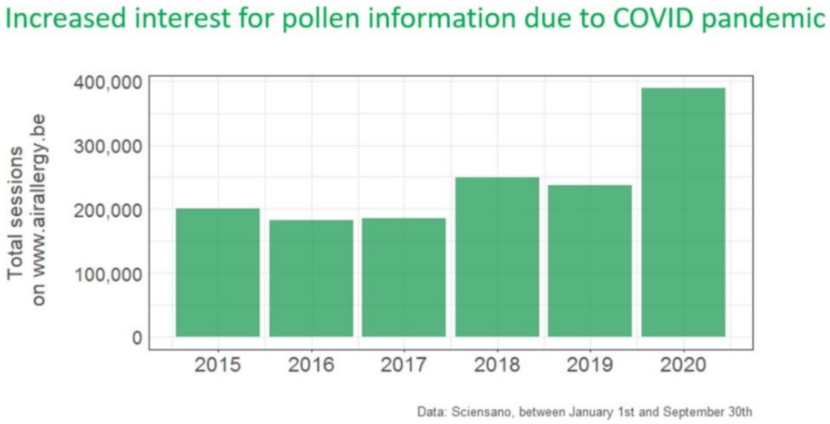

Figure 5-21 Number of viewers on the AirAllergy website of Sciensano

Still, the limited availability of aerobiological and epidemiological datasets makes it difficult to directly and quantitatively associate climate change to the prevalence of allergic diseases (Cecchi et al., 2010). The effect of an increase in length and/or severity of the pollen season on the incidence of allergic rhinitis or asthma has not yet been studied for Belgium or other West European countries. Estimates of the proportion of the population that is allergic to pollen are available. A study of medication sales for childhood asthma indicates that the average period prevalence of sales of medication for obstructive airway disease across sex and age groups varied little between years between 2010 and 2014 (Aerts et al., 2020b). However, the average 12-month prevalence differed significantly between sex and age groups and was highest in the 6–12 year old age groups: boys [PP(SD) 13.5% (4.0)] vs. girls [PP(SD): 10.2% (3.2)] and lower in the 13–18 year old age group: boys [PP (SD): 8.9% (2.5)] vs. girls [PP (SD): 8.1% (2.3)]. However, allergic rhinitis is often self-treated, so data from general practitioners and hospitals are incomplete.

The climate-driven changes in aeroallergens and associated triggered allergic reactions will have implications for asthma prevalence and associated medical costs including medication purchases but also emergency hospital visits (Anderegg et al., 2021). If the period during which people are exposed to pollen prolongs, allergen avoidance as a coping strategy will become more complicated. Costs for the treatment of disease symptoms and allergy therapy as well as those of doctor's visits, admittance to hospitals, sick leave, or measures for limiting pollen exposure will rise with increasing allergen prevalence and exposure. A large share of the costs would be due to the spread of *Ambrosia* and other new allergenic plant species. But it is also worth mentioning that emerging allergic diseases may also appear from endemic or long-standing exotic species that have so far presented a non-allergenic or lowly allergenic profile in Belgium, i.e. ashes and planes for which pollen concentrations have been increasing.

From the interviews with healthcare stakeholders, we learn that less emphasis is currently placed on the risk of aggravated allergies for the health care system. Several stakeholders indeed point out a higher prevalence of inhalers in their general patient population, but find that this does not pressure or change their daily work significantly as medical guidelines exist and are well known. No specific risk groups were identified (Anonymous, 2021a).

5.4.2.6 Respiratory diseases and asthma

As discussed in section 2.1.7, climate change will probably lead to an increase in background concentration levels of ozone and particulate matter. As health effects due to exposure to particulate matter are developed after long term exposure, one can expect an increase in the associated morbidity and mortality effects. For ozone the picture is less clear as despite the higher background levels the intensity of the ozone peaks is expected to reduce. Health effects due to ozone arise at short-term peak exposure and hence can be expected to decrease.

Certain population groups, including elderly, young children or people already suffering from asthma and respiratory diseases, are most vulnerable to health risks if climate change further increases the prevalence of these diseases.

5.4.3 Current and planned measures

5.4.3.1 Data availability

Pollen and fungal spores: monitoring and surveillance of current situation and short-term forecast

The Belgian aerobiological surveillance network[1] (AirAllergy) managed by Sciensano is the only long-term monitoring in Belgium of outdoor aeroallergens (pollen & fungal spores) levels by the standard Hirst method. It provides a NRT visualisation of measurements in the outdoor air of five monitoring stations for pollen of grasses (see e.g. Figure 5-22), birch, alder and hazel, mugwort, ash, oak, and fungal spores of Cladosporium, Alternaria and Basidiomycota.

For some of these pollen and fungal taxa, a specific concentration threshold value exists, above which it is considered that most of the allergic patients are at high risk to feel their symptoms. However, these thresholds are based on the review of past scientific studies conducted abroad. The refinement and the definition of new symptomatic thresholds, updated for the Belgian population and taking into account environmental settings (air pollution, weather conditions), are among the objectives of the Belspo-BRAIN RetroPollen project.

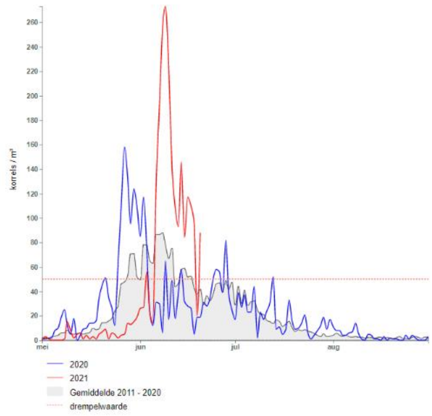

Figure 5-22. Time line of grass pollen concentrations for the current (red) and previous (blue) year. Source: https://airallergy.sciensano.be/nl.

[1] https://airallergy.sciensano.be

The timing and intensity variations of the season periods for the main allergenic pollens are being assessed annually. The AirAllergy website proposes an updated seasonal calendar which displays the average season periods for a series of pollen and fungal spore taxa, ranked by allergenicity.

Concerning monitoring, Sciensano plans to purchase a first automatic real-time device for pollen and fungal spore monitoring in Brussels (European open tender launched on May 2021). The monitoring results will be in depth analyzed and compared to the measurements from the standard Hirst method during a series of seasons. This new technology will offer many perspectives for the AirAllergy end-users and for the aforementioned forecast development with RMI.

The Royal Meteorological Institute has been developing, in collaboration with Sciensano, a forecast system for airborne pollen levels in Belgium[1]. It is based on a particle dispersion model called SILAM (System for Integrated modeLling of Atmospheric coMposition) that takes into account meteorological parameters and pollen emission maps. Sciensano pollen data help to validate these predictions. Current prototype model specifically works for birch and grass pollen in a 3-days forecast system. From the scientific point of view, SILAM is so far considered among the most credible forecast models available, together with COSMO-ART. Until this spatio-temporal forecast system is reliably operational for Belgium (planned at the end of the Belspo-BRAIN RetroPollen project in 2024), a simplified daily risk index for hay fever is estimated by Sciensano, based on pollen measurements and short-term weather forecast, during the grass pollen season (from May 15th to July 15th) on the RMI website.

Ragweed is one of the species taken up in The Global Register of Introduced and Invasive Species (GRIIS) for Belgium. This register contains information on 3,000+ validated non-native taxa in Belgium and serves as the national reference for the Global Register of Introduced and Invasive Species (Pagad et al., 2018). Within the Belspo-BRAIN TrIAS project, distribution maps have been derived for various invasive alien species, including ambrosia species[2]. The TrIAS project was set up in the framework of measure 5 of NAP2017-2020 to take climate change into account in risk analysis for invasive alien species (NAP, 2017). The left panel of Figure 5-23 shows a timeseries of (non-systematic) observations in Belgium. Within the ENVIeS-plan of the Walloon Region an action aims to optimise the monitoring network and the exploitation of the results, with a particular focus to intensify the surveillance and monitoring of ragweed (SPW Environnement-santé, 2019). This resulted in the creation of the 'Observatoire wallon des Ambroisies'[3] in collaboration with University of Liège. In 2020 a network of observers was set up to collect and validate a maximum number of occurrences of the species in synergy with the stakeholders in the field. In this way the first characterisation of the distribution of the species in Wallonia and the most favourable areas for its establishment (invasion hotspots) were identified, see right panel of Figure 5-23.

[1] https://www.meteo.be/en/projects/retropollen
[2] https://trias-project.github.io/risk-maps/
[3] https://www.gembloux.ulg.ac.be/biodiversite-et-paysage/2019/12/02/lobservatoire-wallon-des-ambroisies-est-ouvert/

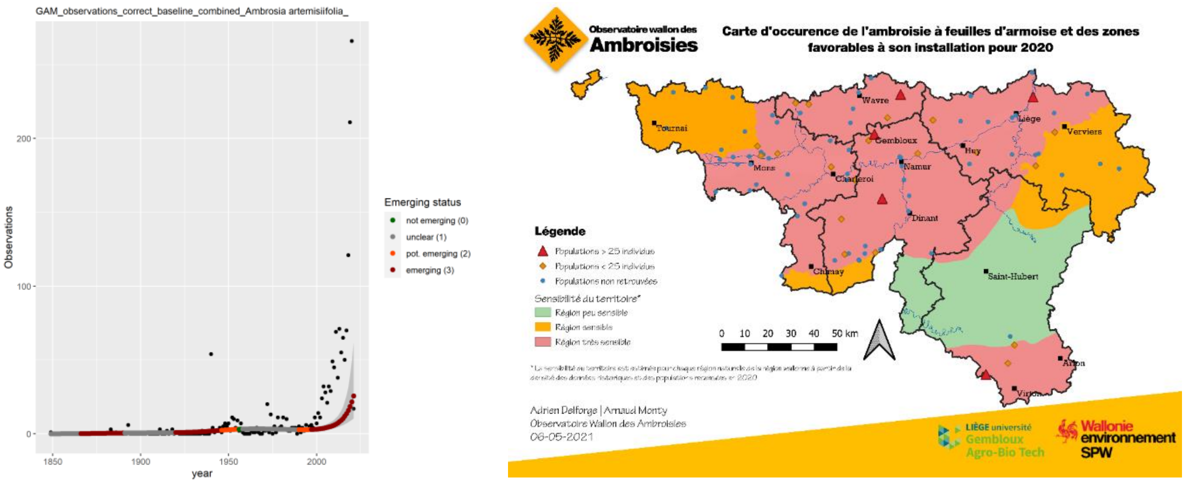

Figure 5-23. Occurrence of ragweed. Left: Time series of observations in Belgium (TrIAS), Right: Map of the occurrence of ragweed and areas favourable to its establishment for 2020. Source: https://www.adalia.be/actualites/articles/lambroisie-feuilles-darmoise-apres-un-quen-est-il

On the aforementioned Belgian nature platform Waarnemingen.be people can report the occurrence of ragweed plants, this provides the only (passive) monitoring in Belgium.

Air quality: monitoring and surveillance of current situation and short-term forecast

Ambient concentrations of various air pollutants are being monitored by Agence Wallonne de l'Air et du Climat (AWAC), Bruxelles Environnement and Vlaamse Milieumaatschappij (VMM), IRCELINE makes all data available on their website. On the basis of these measurements a spatial interpolation model is used to reflect the current situation of air quality for the entire territory of Belgium[1]. On the basis of measurements and weather forecast air quality forecasts are given two days in advance.

In case of (predicted) enhanced particulate matter and/or ozone concentrations, the population is being informed by different media. One can also subscribe to a mailing list and install the BELAir app (see also section 5.1.3.1.1). The measured and predicted ozone concentrations are also taken into account by the Risk Assessment Group (RAG) in order to activate the alarm phase of the ozone and heat plan (see also section 5.1.3.2).

5.4.3.3 Information, sensibilization and prevention of general population

Concerning education of patients with pollen allergy about the risk of asthma exacerbation and about proper treatment of rhinitis and asthma, there is no structural measure that has been developed at national or regional level.

There is preventive information provided by Sciensano (AirAllergy) and education of asthmatic patients is provided though their individual follow-up by their medical doctor.

Concerning ragweed, the 'Observatoire wallon des Ambroisies' started a sensibilization campaign in 2021. They will prepare communication material on the recognition, nuisance and control techniques of ragweed for different stakeholders, a.o. farmers.

5.4.3.2 Information flow to medical practice

Regularly education programs are organized by scientific/medical associations for general medical workforce and pharmacists in the recognition of allergic disorders and about their increased

[1] https://www.irceline.be/nl

prevalence and altered seasonality, e.g. ABEFORCAL (Association Belge de FMC en Allergologie), BelSACI (Belgian Society of Allergy and Clinical Immunology), EAACI (European Academy of Allergy & Clinical Immunology), etc.

E-learning modules are currently being developed through NEHAP and will give healthcare professionals a more in-depth formation on problems related to climate change and other environmental stressors, this is further detailed in section 6.1.3.1.

5.4.3.3 Spatial planning considerations

Building regulations can improve indoor climate quality for moulds specifically as due to climate change winters are expected to become wetter as detailed in section 2.2 (D'Amato et al., 2020; Katelaris and Beggs, 2018). The EPB-legislation sets requirements for creating an energy efficient and healthy indoor climate. The EPB-legislation is taken up in the national as well as the regional energy climate plans, see section 5.1.3.3.

The Flemish Department of Environment is currently investigating how green and blue spaces can serve as building blocks for resilient healthy living environments. The study also takes pollen and allergies into account, results are expected end of 2021.

5.4.3.4 Control measures of ragweed

There is a legal standard for ambrosia (all species) in feed: EU Directive 2002/32/EC[1] on undesirable substances in animal feed. Seed mixtures for outside birds must not contain more than 50 milligrams of ambrosia seeds per kilogram. The Belgian Feed Association performs analysis of animal feed (including bird seed) for the presence of ambrosia, no non-conformities have been reported in recent years (BFA, personal communication June 2021).

Within the 'Observatoire wallon des Ambroisies' the best prevention and control techniques for ragweed will be identified on the basis of a literature review, aiming to the implementation of field actions to eliminate the areas of invasion.

5.4.4 Gaps between risks and current/planned measures - Adaptation actions and recommendations

5.4.4.1 Data availability on allergies and respiratory diseases

We mentioned in section 5.1.4.1.2 the lack of (near-) real-time information from general practitioner visits. As mentioned in section 5.4.1.1, allergic rhinitis is often self-treated, so data from general practitioners and hospitals are incomplete.

Despite the long-term and continuous monitoring of airborne ragweed pollen at 5 sites in Belgium by Sciensano, no active surveillance or monitoring system is available for ragweed plants distribution in Flanders. This contrasts with initiatives taken in the Netherlands[2], France[3], Germany[4], etc.

5.4.4.2 Prevention

Concerning diagnosis and treatment, there is no structural support on adapted management of aeroallergen sensitization and allergies. There exist no structural initiatives on the improvement of allergen characterisation and treatments to reduce the morbidity linked to aeroallergen exposure. This might explain why allergies are diseases so under-diagnosed and under-treated as detailed in section 5.4.1.1.

[1] https://eur-lex.europa.eu/legal-content/NL/TXT/PDF/?uri=CELEX:02002L0032-20171225&from=EN
[2] https://waarneming.nl/
[3] https://solidarites-sante.gouv.fr/sante-et-environnement/risques-microbiologiques-physiques-et-chimiques/especes-nuisibles-et-parasites/ambroisie-info/espace-professionnels/ambroisie-info/reglementation
[4] https://pflanzengesundheit.julius-kuehn.de/ambrosia-gefunden.html

5.4.4.3 Spatial planning considerations

Despite interest from citizens, associations and local authorities, adapted management of green spaces, specifically in urban areas, in relation to aeroallergen exposure, has not been implemented yet. The PollenPark study demonstrated that removing Betulaceae from urban green spaces would only marginally reduce the allergenic potential of parks in Brussels (Aerts et al., 2021). Allergenic tree diseases and preventive removal of the main allergenic trees may only partially mitigate allergy risks that are amplified by environmental change. While it may be worth to invest in the establishment of new hypoallergenic green spaces in and near cities, the removal of allergenic tree taxa such as Betula and Platanus from existing green spaces is not recommended in the light of the conservation of biodiversity and important ecosystem services (Aerts et al., 2021).

In a case-study for Brussels the allergy risk of 18 green spaces has been determined based on tree inventory data (Aerts et al., 2021). At a larger scale airborne LiDAR and hyperspectral imagery can be used to identify individual tree species (Mäyrä et al., 2021). This allows to derive Belgium-wide allergy risk indices e.g. at the level of the statistical sector.

5.4.4.4 Surveillance and control measures against climate-related invasion of exotic species

As mentioned in section 5.4.3.4 there are plans for controlling ragweed in Wallonia. In Flanders there are no control measures in force. However in the neighbouring countries control measures are in force, e.g. the Netherlands[1], France, Germany[2]. In France the Ministry of Health issued a guideline[3] for local authorities with different controlling techniques and information for awareness rising.

Individual or local authority control is recommended, depending on the location and number of specimens found. Control measures vary depending on whether the plants are in bloom or not. When removing flowering plants, more precautions should be taken (e.g. wearing a ffp2 mask) to minimise pollen exposure. The cut plants should not be composted but treated as rubbish.

Regarding the emergence of the allergenic fungus *Cryptostroma corticale*, no monitoring and/or control measures against the maple bark disease have been structurally set up at national level. So far, only short guidelines have been published by the Public Waste Agency of Flanders (OVAM)[4].

5.4.4.5 Research

Extended research will be necessary to fill the large knowledge gaps not only on the known allergenic pollen and fungal spores but on the exposure of the airways to all types of bioaerosols (bioexposome), the identification of their health impacts, either as direct effect, additive or synergistic effect, as connected with multiple allergic/non-allergic diseases and for risk populations. It is also crucial to focus investigation on bioaerosol exposure in the context of climate change, by detecting for newly emerging bioaerosols, further evaluating the changing exposure seasons and severity, altering health outcomes like airway immune deficiency, compromise of the immune system, sensitization to non-pathogenic bioaerosols, symptomatology, and their relation to single/multiple exposures. Health impact assessment should be overtaken in a non-anthropocentric One Health perspective.

[1] https://www.nvwa.nl/onderwerpen/ambrosia
[2] https://pflanzengesundheit.julius-kuehn.de/index.php?menuid=60&reporeid=212
[3] https://solidarites-sante.gouv.fr/IMG/pdf/guide_gestion_agir_contre_l_ambroisie-2.pdf
[4] https://www.ovam.be/bomen-besmet-met-roetschorsschimmel-richtlijnen

5.5 EFFECTS ON MENTAL HEALTH

5.5.1 Current situation

Mental health is both directly and indirectly affected by physical effects of climate change on the environment.

Natural disasters such as severe storms, wildfires and floods can lead to damage to or loss of property and other physical impacts in the environment (USGCRP, 2016). This can cause direct psychological effects, such as increased rates of depression, anxiety, post-traumatic stress, substance use or misuse, suicidal thoughts and other mental health disorders (Cianconi et al., 2020). In the case of loss of property, a forced relocation can also lead to destruction of the social network. Large scale destruction can disrupt existing social networks and harm community resources. One should note that the associations between extreme weather outcomes and human behaviour are complex, there are many confounding factors.

In section 5.1.1.7 we discussed the effects of extreme heat on mental health.

There are also psychological effects of climate that are not directly related to a climate event such as extreme weather. **Climate anxiety**, eco-anxiety, climate distress, … are terms that describe anxiety related to the global climate crisis and the associated treats. Symptoms associated with climate anxiety include panic attacks, insomnia and obsessive thinking (Wu et al., 2020). In a recent poll[1] carried out in France, 85% was worried about global warming, with this figure rising to 93% among young adults aged 18-24 years. It is unclear to what extent the Belgian population is affected by feelings of climate anxiety.

Experience from the stakeholders learns that elderly individuals who live at home (alone) are identified as an important risk group since they may be more susceptible to feelings of anxiety and **loneliness**. Visiting friends or family members who reside in a residential nursing home, psychiatric hospital, a centre for people with disabilities etc. becomes more difficult in the case of extreme weather conditions (such as heat, heavy winds or rainfall etc.). Not having the possibility to go for a walk outside with visitors also has a negative effect on the welfare of both patients as well as family and friends. This impact is felt very strongly by health care professionals in these institutions.

More information regarding the impact of heat and other climate indicators on mental health is presented in Ščasný et al. (2020).

5.5.2 Expected changes

As outlined in chapter 2 the occurrence and intensity of natural disasters and extreme events is expected to increase in Belgium due to climate change. This will give rise to an increase of mental health problems due to:

- damage to or loss of property during extreme weather events;
- exposure to extreme heat;
- climate anxiety;
- loneliness.

For patients with pollen allergies, changes in airborne pollen concentrations may also have an impact on mental health, as pollen allergy induces seasonal distress in tree pollen allergy patients (Aerts et al., 2020c). As pointed out in section 5.4.2.1, the increase of intensity and length of the pollen allergy seasons, during which people with allergies spend more time indoors, might lead to less social

[1] https://www.ifop.com/publication/les-francais-et-le-rechauffement-climatique-balise-dopinion-42/-

contacts, outdoor sporting or recreating possibilities and hence might increase feelings of loneliness.

The aspect of mental health also became evident during the COVID-19 pandemic, which may give us some indication of the impact of vector-borne diseases due to climate change. Health care actors have noticed an increase in anxiety (fear to get sick, to attribute to the disease of a family member, …) and an increase in loneliness and social isolation. The occurrence of extreme weather conditions with heavy wind, storms or heavy rainfall are also expected to increase feelings of anxiety and insecurity related to climate change, also referred to as eco-anxiety.

Various climate-related risks (such as increased temperatures) lead to poorer sleep quality. A lack of sleep can delay or disturb a patient's recovery process.

5.5.3 Current and planned measures

5.5.3.1 Post-disaster social care

In the Hospital Emergency Plan that defines uniform structures and procedures for various hospitals in Belgium in case of an emergency event (more information in section 3.4), special attention is given to psychosocial assistance, communication with relatives and victim registration and general information management. Also at longer durations, post-disaster attention must be paid to psychosocial assistance (HSPA, 2020).

A recent longitudinal analysis of Hurricane Katrina (2005) shows that social support soon after the event is positively associated with physical health and mental health years later (Ha Bui et al., 2021).

5.5.3.2 Spatial planning: green and blue infrastructures

As mentioned in section (5.1.3.4) green and blue spaces provide besides cool spaces during periods of heat, also other benefits for environment, health and society.

There is strong evidence of the mental restoration benefits of green space, related to avoiding chronic stress and attentional fatigue (WHO Regional Office for Europe, 2016). Spending time in nature reduces feelings of anxiety and depression, while a lack of green space is associated with increased symptoms (Maas et al., 2009). Green spaces provide an arena for social interaction, reducing feelings of loneliness, it has been demonstrated that simply viewing nature enhances emotional well-being (Morris, 2003). The direct benefits for health and well-being depend on an individual's interaction with the space, which is influenced by both the characteristics of the space, such as access, quality and safety, and personal choices and capacities. The accessibility of green and blue spaces to different social groups determines how benefits are distributed across society. The presence of green space in a local neighbourhood is especially important for socially deprived populations, children and the elderly (EEA, 2020c). As mentioned before, even for tree pollen allergy patients two recent Belgian studies demonstrated that both residential and dynamic exposure to green space reduce mental distress (Aerts et al., 2020c; Stas et al., 2021).

The uptake of green and blue spaces in the proximity of hospitals and residential care homes is a new trend in Belgium[1].

Implementation of green-blue infrastructures at regional scale

One of the five strategies of the Flemish Adaptation Plan 2021-2030 is the optimization of green and blue networks. At the regional level they are aiming to form a green-blue network of large contiguous areas (including industrial and agricultural areas), interconnections and smaller fragments in or near the city, whereby fragmentation is avoided. The ecological connectivity of the space will be increased by an adapted nature-friendly management, by the construction of linear green elements along

[1] https://zorgwijzermagazine.be/milieu_preventie/transformatie-van-ziekenhuissite-naar-gezondheidscampus/

motorways, waterways and railways, walking and cycling paths, by the construction of eco-ducts, eco-tunnels and other wildlife corridors, and by thoughtfully constructed green infrastructure on business estates and in urban areas. After approval of the Flemish adaptation plan, the different strategies will be materialized in a multi-annual action plan. The strategy coordinator of the green and blue networks strategy is INBO and Flemish Department Environment.

The PWEC foresees that regional and municipal levels cooperate in the implementation of green infrastructures at the local and regional scale. They mention as an action the recent development of a new Forest Code[1] by SPW-L'environnement en Wallonie. The code explicitly mentions that forests should be capable to resist climate change effects, biodiversity should be increased and that the social role of forests for recreation should be reinforced.

For the Brussels Region the Management Plan of the Zoniënwoud/Forêt de Soignes states that the main objective is to turn the forest into a recreational green space taken account ecological aspects. Brussels Environnement also provides green and blue networks[2] to link green spaces and water areas, recreation is one important aspect in the development of these.

5.5.4 Gaps between risks and current/planned measures - Adaptation actions and recommendations

The effects on mental health concern health care professionals across all levels and types of institutions, this was made clear during the interviews with the stakeholders. They noticed that the effects on mental health are not adequately prepared for or sufficiently foreseen. Especially for patients in psychiatric institutions as they are less able to take the appropriate small preventive actions themselves (Anonymous, 2021a).

5.5.4.1 **Risk communication**

When it comes to the communication of the risks of climate change to the general population, there is variation depending on the risk factor. In terms of heat-related risks for example, information measures seem to be well spread. The question that many stakeholders pose here is to what extent this information is absorbed by the general population, thereby creating the necessary awareness. Groups such as elderly individuals, those in lower socio-economic groups and individuals with a foreign background are noted as vulnerable groups once again, since there are additional barriers to spreading this information in an efficient and sufficient manner as well as fully grasping its impact (Anonymous, 2021a).

An element that stands out, both from the interviews as well as online survey among the sector that comes forward is a lack of communication concerning the **benefits** of prevention regarding these risks. (Anonymous, 2021a, 2021b).

Firstly, there seems to be a consensus that there is insufficient information on the potential of preventive health care for the general population. It has been noted that emphasizing the potential benefits of even small preventive action of individuals can give a stronger sense of security and self-efficacy, countering potential feelings of anxiety and helplessness as well as reducing physical health risks simultaneously. The importance of early detection and (small) preventive actions is central in the approach towards the general population.

Secondly, issues in terms of prevention are identified at government level as well, including a lack of incentives for preventive healthcare throughout the sector. As a consequence of this lack of incentives, or due to misaligned incentives, there is a suboptimal level of preventive healthcare which affects information and communication on preventive actions. We further detail on this in section 6.1.1.

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[1] http://environnement.wallonie.be/publi/dnf/codeforestierfr.pdf
[2] https://leefmilieu.brussels/themas/groene-ruimten-en-biodiversiteit/acties-van-het-gewest/de-netwerken

5.5.4.2 Research

In the survey, medical doctors active in psychiatric hospitals point out that more research is required on the impact of heat on the effectiveness of medication for psychological symptoms, while this is available and well known for medication treating somatic symptoms (Anonymous, 2021b).

6. HEALTHCARE PERSONNEL

Within the survey, we enquired about climate-related effects that may have a negative impact on the well-being of healthcare workers (Anonymous, 2021b). The results are summarized in Figure 6-1, nearly 90% of healthcare actors thought extreme weather events to have adverse effects, but also more than half of the respondents is feared and insecure about what the impact will be like. A quarter of the institutions fears a high influx and insufficient capacity.

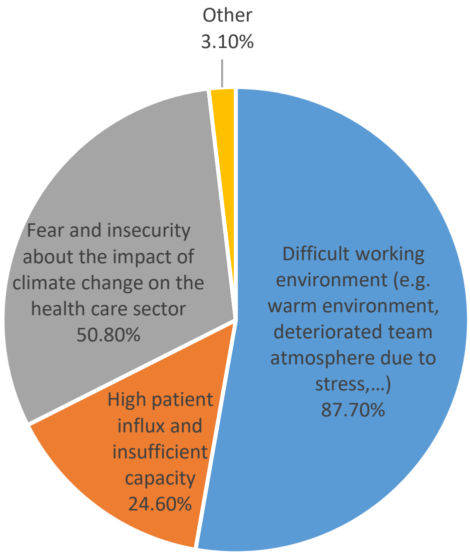

Figure 6-1. Reasons contributing to a deteriorating impact on the well-being of healthcare workers.

Below we focus on the climate effects on the requested training and skills for healthcare personnel, workload and peak capacity.

6.1 TRAINING AND SKILLS

6.1.1 Current situation

Integrated healthcare services cover health promotion, disease prevention as well as curative care. The first two focus on the creation of a healthy lifestyle and environment. With the growing number of patients with chronic or pre-existing conditions that make them more vulnerable to various environmental stressors, there is a growing need for health promotion and preventive healthcare. The most recent Health System Review 2020 for Belgium highlights the need for a strengthening of prevention policies in Belgium (Gerkens S, 2020). Currently preventive care takes only 2.16 % of the total expenditure on health.

Health promotion and disease prevention are the responsibility of federated entities, while curative care falls under the responsibility of the federal government. To facilitate cooperation between the federal authorities and the federated entities, inter-ministerial conferences are regularly organized.

6.1.2 Expected changes

Climate change will increase the prevalence of heat-related diseases, especially amongst the most vulnerable populations of young children, elderly, people with pre-existing or chronic conditions etc. Climate change will introduce new diseases (e.g. vector-, food- or waterborne, see sections 5.2 and

5.3) and will exacerbate different diseases, resulting in more complications (e.g. allergies and respiratory diseases, see section 5). It is important to develop preventive measures, symptom recognition and treatment for these (new) pathologies.

Non-climate related there is a tendency towards more extra-muros care allowing patients to remain at home for as long as possible (Gerkens, 2020). This is especially the case for mental, palliative, long-term and rehabilitation care. This evolution requires the further development and deployment of home-based and community-based care offering more effective, accessible and patient-centered care. In this respect it is important to increase the health-literacy of the home- and community-based caregivers as well as of the patients. Patients need information and guidance to adapt their lifestyle during their often-lifelong treatment, also in more extreme weather conditions or crisis situations. In a recent evaluation of self-care through education and support for children and young adults with chronic conditions (e.g. asthma, diabetes mellitus type 1), it turned out that the more the patients were engaged in self-care behaviours, the more the outcomes were favorable (Dall'Oglio et al., 2021).

Experience from the stakeholders learnt that the notion exists among healthcare professionals that the next pandemic or health crisis may be something entirely different and require new types of actions from the sector.

6.1.3 Current and planned measures

6.1.3.1 Education

In the curriculum of healthcare disciplines (caregiving, nursing, medicine, etc.) there are medical courses on heat effects on the human body, infectious diseases, respiratory diseases etc. However, the link between environment and health promotion/prevention is less well covered in the basic training. At some universities one can follow a Master of Science (MSc) in health promotion, the programme provides learning outcomes on health behavior related to environmental conditions. At the Academic Centre for General Practice of the University of Leuven there are several research projects on the surveillance of health effects related to environmental exposure and epidemiology. Within a recent master thesis a heatwave protocol has been worked out for elderly care centres and general practitioners (Berckmans, Janssens, Van Pottelbergh 2020). The thesis gives scientific evidence for existing measures and it includes a proposed heat protocol for elderly care centres and general practitioners. The thesis is available online, however it is a pity that the results are not disseminated actively.

As mentioned before, e-learning modules are currently being developed through NEHAP, this action fits within the NAP2017-2020 that foresaw education and awareness-raising among health professionals on the subject of climate change impacts (NAP, 2017). The training project consists of 11 e-learning modules dealing with various environmental health problems related to outdoor and indoor air quality, noise, climate change, heavy metals, mould, endocrine disruptors, chemical products, radon, as well as on exposition during critical life phases. It aims to train new students or qualified professionals ("Environment and Health Practitioners") on the close links between environment and health. Within this framework, the health and environmental impacts of climate change are specifically addressed in one module that is structured as follows: pathologies, renal diseases, vector-borne diseases, other diseases, conclusions. The climate module is designed to enable health professionals to identify the direct and indirect health effects of climate change, identify the most vulnerable population groups, detect risks related to vector-borne diseases, have tools to continuously monitor certain risk factors. Health effects of climate change are also addressed in the modules on health and society and the modules on infectious diseases.

6.1.3.2 Knowledge- and good practices sharing

During the COVID-19 pandemic there has been increased sharing of knowledge and good practices amongst the different lines of the healthcare sector (KCE, 2020). The KCE-report mentions that several hospitals supported nursing homes with expertise sharing (e.g. infection prevention and control, management skills) including the efforts of various hospital professionals. Many hospitals also provided equipment, medication, psychological support, etc (KCE, 2020). It can be expected that for new climate-related diseases information exchange on symptom recognition, protective equipment, care etc. there will be a need for a similar knowledge- and good practices transfer within and across the different healthcare lines.

In the only survey, learning new skills was mentioned as a contributing factor to an increased workload for vector-borne diseases (e.g. new medication guidelines, new pathologies, etc.) and to increases in allergies or respiratory diseases (e.g. new medication guidelines due to allergies). These were mainly noted by elderly nursing homes and institutions for persons with disabilities (Anonymous, 2021b).

6.1.3.3 Information flow to medical practice

The communication from epidemiological surveillance institutions to the healthcare sector goes via different channels:

- For the notifiable infectious diseases, the regional healthcare authorities (AZG, AVIQ, COCOM) set up the communication towards healthcare personnel. In case of a local infection, the communication is only in place in a limited area around the source of the infection. Sciensano prepares a monthly “Newsflash infectious diseases” with important epidemiological trends in Belgium and abroad. The bulletin is distributed by AZG, AVIQ and COCOM to medical practices and anyone who has subscribed to the newsflash, the bulletins are also freely available online[1]. AZG has an interactive tool to display annual data starting from 1999[2]. The regional healthcare authorities inform RAG (see section 3.5) and Sciensano.
- For the different surveillance systems, the results are summarized in annual reports[3], the results of the surveillance systems are also made available via an interactive dashboard[4], for professionals there is a version of the dashboard that allows for more detailed insights and analyses.
- For specific projects and themes, press releases are sent out at important moments, which reach the general public and thus also the medical practice; e.g. start of the tick season, evolution of the flu epidemic.
- In the event of a major health crisis, the RAG, coordinated by Sciensano, may be tasked with drafting -guidelines and procedures and communicating them proactively to medical practices.
- In case of serious outbreaks or findings, ECDC and health services in neighboring countries are alerted. In case of new developments abroad, the national and regional health authorities are informed by instances such as ECDC, but also health authorities in France (ANSES), the Netherlands (RIVM), etc.
- In principle, the FPS-Health only takes action and communicates in the event of a health crisis and/or disaster.

During the interviews with healthcare stakeholders, it is pointed out that doctors, caregivers etc. are well aware of the required medical guidelines and are trained for the treatment of somatic health risks associated with heat and allergic reactions (Anonymous, 2021a). From the interviews, we learned that once new pathologies are communicated towards the healthcare systems, communication channels within the sector are in place to disperse information related to these new pathologies within the health care institutions. Spreading this new information within health care institutions is not viewed as a major risk factor by stakeholders.

Despite the availability of information channels mentioned above, in the online survey among stakeholders in the healthcare sector only 18% of the respondents noted they are currently receiving alerts on the detection of vector-borne diseases, 52 % indicated they would like to receive additional

[1] https://epidemio.wiv-isp.be/ID/Pages/flashs.aspx
[2] https://www.zorg-en-gezondheid.be/cijfers-over-meldingsplichtige-infectieziekten-0
[3] https://epidemio.wiv-isp.be/ID/Pages/Publications.aspx
[4] https://epistat.wiv-isp.be/

information. Some issues concerning the implementation as discussed below.

6.1.4 Gaps between risks and current/planned measures - Adaptation actions and recommendations

6.1.4.1 Education

In the curriculum of healthcare disciplines (caregiving, nursing, medicine, etc.) a bigger focus on environmental determinants of health, could create a more preventive reflex towards patients. This learning section should be more theoretical for medical students and more practical for nursing and caregiving students. The aforementioned NEHAP e-learning modules will address this need.

For the education program of non-medical disciplines too, it would be beneficial to incorporate a module on health promotion and preventive healthcare and the link with environment. After all health promotion and preventive healthcare is highly multidisciplinary, and involves people with backgrounds in behavioral sciences, social sciences, medical and paramedical sciences, communication sciences etc. Among the environmental treats for health, up-to-date information on climate change could be provided.

6.1.4.2 Knowledge- and good practices sharing

For non-residential health and care (e.g. general practitioners and health community centres) no specific heat plan is required. Throughout the interviews, it has not been signalled that this should be required, though minimal requirements and guidelines can be useful as well as the sharing of good case practices among health care professionals (Anonymous, 2021a).

6.1.4.3 Information flow to medical practice

As mentioned in the previous section, communication channels are in place to disperse information related to the treatment of new pathologies throughout the sector. It has however been pointed out that communication issues may arise because of a lack of one clear point of contact (e.g. during COVID-19). Multiple institutions with responsibilities towards the health care network and the division of responsibilities across federal and regional governments, create more complexity in emergency or crisis situations that may already by chaotic. It should be pointed out however that these different institutions virtually always agree on their guidelines and information towards the sector. For personnel to adapt in a timely and orderly fashion, it is crucial for them to have a clear point of contact who is aware of its responsibilities in a health care crisis, in order to optimize communication channels (Anonymous, 2021a).

Concerning information from surveillance, it was mentioned before that the perception exists that healthcare workers do not receive all newest information on the occurrence and spreading of disease cases identified nationwide and beyond (Anonymous, 2021a). Additionally, it was mentioned that the information is rather fragmented and often not covering the entire country. The fear exists that this may result in late identification of certain new epidemiological trends (Anonymous, 2021a).

Health literacy for patients

To make home and community-based care a success, it is necessary that patients have sufficient resilience to cope with their diseases and to remain mentally and physically healthy, to the best possible extent, in their living circumstances. There is a need for a conceptual model of health literacy in order to allow patients to manage their own health, incorporating both health promotion and disease prevention. Sørensen et al. (2012) developed an integrative conceptual model, containing 12 dimensions referring to the knowledge, motivation and competencies of accessing, understanding, appraising and applying health-related information within the healthcare, disease prevention and health promotion setting, respectively.

In the context of **population health management**, a wide view on all determinants of health is required. Within this approach one aims to improve the quality of care and health outcomes of a group of patients, this works well for e.g. diabetes patients (Schmittdiel et al., 2017). A similar management system could be set up for people with an increased risk for developing heat-related symptoms. In the UK population health management systems have been implemented successfully[1].

It is not clear who can take a leading role in the development and application of health literacy models or population health management systems. Local implementation is essential and might include home nursing organizations and/or general practitioners.

Research

In the survey, medical doctors active in psychiatric hospitals point out that more research is required on the impact of heat on the effectiveness of medication for psychological symptoms, while this is available and well known for medication treating somatic symptoms (Anonymous, 2021b).

6.2 WORKLOAD DUE TO EXTRA CARE

6.2.1 Current situation

Healthcare workers face many mental and often also physical workloads. For nursing and caring personnel physical activities such as lifting patients and standing for hours, can lead to ergonomic complaints. The high work pressure and irregular hours may cause stress, burn-out and dissatisfaction.

During current heat waves of higher temperatures, health care personnel often work in difficult working conditions, putting additional strain on the intensive care tasks.

It should be pointed out that – even in regular working conditions – health care institutions usually work at maximum capacity and there is a general lack of nurses, caretakers or other healthcare professionals. In case of understaffing moral stress can play as care providers cannot offer the quality of care they believe in. This is a long-lasting problem for the healthcare sector in the different lines in Belgium.

6.2.2 Expected changes

With the increase in frequency, duration and intensity of heatwaves, extra care is expected in hospitals and residential care homes: patients need to be cooled, medication schemes adapted. The healthcare personnel needs to be vigilant in order to recognize early symptoms. Also during the night there might be a need for more staff as patients/residents have sleeping problems.

The local implementation of heat-health action plans will require more personnel, certainly if one aims to address vulnerable people living (alone) at home.

But also expected increasing numbers of patients with allergic diseases, vector-, water- and food-borne diseases as well as casualties from floods or wildfires, will require more care.

As mentioned in section 5.1.2 non-climate related tendencies such as ageing population, the further development of home-based and community-based care will require additional healthcare personnel.

When asking healthcare institutions to what extent they are worried about the impact of climate risks on workload of healthcare personnel, answers across communities and regions were very similar, see Table 6-1 (Anonymous, 2021b). The main concern – consistent with previous answers – was the impact of heat waves and heat-related disease. The only notable differences between institutions were the following:

- **General and academic hospitals** being more concerned about the impact of extreme weather

[1] https://www.england.nhs.uk/integratedcare/what-is-integrated-care/phm/

conditions. This is not unexpected since this is the only type of healthcare institutions in this survey that is impacted by an increased inflow of patients due to e.g. accidents during extreme weather conditions;

- **Psychiatric institutions** are more worried about the mental impact on healthcare personnel.

Among federal personnel, Medex also indicates increases in accidents on the road due to extreme weather conditions which is noted through their annual reports on absenteeism among federal personnel (Anonymous, 2021a).

Table 6-1. Survey question: "How worried are you about the impact on workload for healthcare personnel due to the climate risks below?"

	Not worried	Rather not worried	Rather worried	Worried	I don't know
Heat waves and heat-related diseases	3%	14%	30%	52%	1%
Vector-borne diseases	11%	51%	22%	11%	6%
Extreme weather conditions	8%	41%	37%	11%	2%
Pollen, allergies or respiratory diseases	11%	51%	27%	8%	3%
Mental impact	5%	31%	35%	26%	4%

Following up on the survey question which asked which climate risks would create an increased workload, health care institutions were also asked what the reason(s) could be for this increased workload if they found that this was a concern.

According to more than half of health care institutions, an increased workload due to new care-related tasks was noted as an important underlying reason. New care-related tasks could be filling it at other departments or nursing units, providing cold beverages, increased number of tasks due to emergency planning during extreme weather conditions,… (Anonymous, 2021b)

Over half of health care institutions is (at least) rather worried about the mental impact of this increased workload for health care personnel. When asked which factors would create this pressure, 86% of respondents noted difficult working conditions (e.g. hot environment, deteriorated team atmosphere due to stress, etc.) as a contributing factor. This was followed by fear and insecurity about the impact of climate change on the healthcare sector (54%). (Anonymous, 2021b).

6.2.3 Current and planned measures

There has been increased attention to the wellbeing of healthcare personnel. Several health care professionals point out that increased temperatures (causing more strained work days as well as lower quality sleep) cause more fatigue. This in turn affects the ability to work efficiently. As is done for patients, small gestures are made in order to 'lighten the load' for healthcare professionals such as lighter clothing, the provision of ice cream throughout the work day. While these are of course helpful, demanding care activities need to be performed in often very warm and uncomfortable conditions, creating more fatigue than otherwise. (Anonymous, 2021a)

Additionally, attention has been raised to the importance of team atmosphere. When tensions already exist before tense events occur, personnel will have more difficulties in coping with these events. This also goes for infrastructure that increases comfort versus working in an environment where infrastructure creates additional issues. A change noted by several stakeholders as well is that healthcare personnel has become more vocal about difficult working conditions, leading to increased attention to aspects of wellbeing for healthcare personnel. (Anonymous, 2021a)

In order to strengthen and support the healthcare personnel during the current COVID-19 pandemic, the Interministerial Conference on Public Health has developed several projects. An overview of the implemented projects as well as of the planned projects is available online[1].Some projects are directly related to COVID, but others are generally applicable, or can be applied in other crisis-situations too. E.g. the delegation of activities for health care professions to persons who are not authorized to do so by law under certain conditions (e.g. delegation from home care nurses to home care, delegation from nurses to care worker ('zorgkundige' in Dutch, 'aide-soignant' in French), etc. [2]). Training placements for health professionals are aligned with real needs. Retired health care workers who have responded to the call for help, can combine the resulting income with an income from a pension. A list has been drawn up of officials who have a healthcare diploma and can possibly be outsourced to the healthcare sector. In relation to the latter two actions, in France and Hungary there exist lists of reserve doctors who can be called to service in case of a sudden surge in demand for health care (HSPA, 2020).

6.2.4 Gaps between risks and current/planned measures - Adaptation actions and recommendations

The main gap is the general lack of sufficient healthcare personnel, and their financing, throughout the entire healthcare sector.

During extreme weather conditions such as heat, the current practice in residential care of cancelling non-essential activities in order to compensate for the extra heat-related care is not sustainable. This might work for a limited period of time, but not throughout an entire summer. Instead more healthcare personnel is needed in order to guarantee a high level of care during extreme weather conditions.

The current funding system in the health sector is performance-based. People consult a general practitioner when they feel ill, home nursing takes care of everyday care. Time constraints often impede the caregiver to give further advice on health promotion or disease prevention activities. This observation was confirmed in a recent multinational survey on engagement of health professionals in education and advocacy on climate-related health issues (Kotcher et al., 2021).

It is not clear who can take a leading role in the development and application of health literacy models or population health management systems. Local implementation is essential and might include home nursing organizations and/or general practitioners.

For vulnerable people living alone at home, especially elderly people, chronically ill or psychiatric patients, extra vigilance is needed in extreme situations. Extreme weather might cause people to remain at home, this makes social control or spontaneous visits to the vulnerable group, less likely. In the interviews the suggestion was given that in order to guarantee proper prevention and vigilance during home nursing, the number of visits should be doubled during episodes of extreme weather.

6.3 PEAK CAPACITY DUE TO INFLUX OF PATIENTS

A sudden influx of patients during a crisis situation has an impact both on the healthcare personnel as well as on the capacity of the healthcare infrastructure. We cover both aspects in this section.

6.3.1 Current situation

During the COVID-19 pandemic the capacity of hospitals has been increased. Concerning the availability of hospital beds, this was mainly related to intensive care (IC) beds. The capacity of personnel had to be increased as the care of COVID-19 patients is very time- and labour-intensive.

For heat-related pathologies there is generally no IC needed, the influx of patients occurs during the summer which is generally a period when the availability of hospital beds is not a problem. However

[1] https://www.info-coronavirus.be/nl/maatregelen-versterking-gezondheidszorg/
[2] http://www.ejustice.just.fgov.be/cgi/article_body.pl?language=nl&caller=summary&pub_date=2020-11-06&numac=2020010457%0D%0A#end

this is traditionally a holiday period that might require more staff.

In case of extreme weather, the environmental effects are localized and there has not been a need to surge capacity so far in Belgium.

6.3.2 Expected changes

6.3.2.1 General

The risk assessment of reaching peak capacity and the impact on staffing differs between healthcare institutions. However, it has been noted by all institutions that understaffing is a general problem in terms of caretaking and medical personnel (Anonymous, 2021b).

For the **curative care** one can expect an increase in hospitalizations and GP visits due to more frequent and more intense extreme weather conditions. For heat-related pathologies, an increase in the length of in-hospital stay has been observed in Australia, this is possibly related to an increasing disease severity (Wondmagegn et al., 2021b). For new diseases it is unclear how this will impact peak capacity of hospitals and other healthcare institutions.

For general practitioners (GPs), there is indeed a risk of reaching peak capacity, so longer work days do occur in times of crisis. This of course can create mental strain and exhaustion. More attention to a simplification of the administrative burden can relieve some pressure and – also in normal working conditions – can increase the satisfaction they receive from their jobs, thus increasing resilience in crisis periods.

Within hospitals, opinions differ, but there is a worry that it will be difficult to cope with very large influxes in more extreme weather conditions aside from heat or from new pathologies. The COVID-19 pandemic has increased awareness and improved the measures taken for viruses similar to it. The notion exists among healthcare professionals that the next pandemic or health crisis may be something entirely different and require new types of actions from the sector.

For **home-based care** there might be an increasing demand, especially during the summer. As mentioned before this might impact holiday plans of personnel.

Based on the available heat alerts, action can be taken in a timely fashion. Alerts for more extreme weather conditions such as storms or flooding, are usually communicated directly to the general population and to hospitals, but it is unclear to what extent other institutions are alerted specifically.

6.3.2.2 Cascading effects

The consequences of cascading effects (see section 4.1.1) has not yet been an issue for peak capacity due to climate-related effects. During the COVID-19 pandemic some hospitals experienced difficulties when victims due to other accidents (e.g. fire in large residence, car crashes) needed intensive care[1].

6.3.3 Current and planned measures

When a hospital is confronted with a sudden influx of patients, the Hospital Emergency Plan (HEP, detailed in section 3.4) is initiated. The HEP describes the procedures to quickly increase the capacity of the hospital in terms of number of beds, equipment and staff.

A Hospital & Transport Surge Capacity (HTSC) committee was established early March 2020. It developed measures and guidelines on the surge capacity of hospitals and the transport of patients. Within the EU healthcare-related cooperation between EU member states is being promoted, and

[1] https://www.vrt.be/vrtnws/nl/2021/04/19/ziekenhuisbedden-brand-anderlecht/

measures are in place to facilitate access to cross-border healthcare. The Cross-Border Healthcare Directive (2011/24/EU) clarifies the legal rights of patients in cross-border healthcare within the EU.

Within the Benelux and with the neighbouring countries France and Germany agreements are in place concerning cross-border patient flows, involving both planned as well as unplanned care[1].

For residential care, revalidation centres, centres for people with disability, there is no major influx of patients to be expected.

6.3.4 Gaps between risks and current/planned measures - Adaptation actions and recommendations

In order to avoid an influx of patients during climate-related crisis situations, it is important to increase the **resilience** of the general population and especially of the most vulnerable groups. This can be achieved through strengthening health promotion and preventive care.

The availability of (near-) **real-time monitoring of GP and hospital data** at national level can be used for monitoring the patients, type of pathologies and comorbidities, duration of hospital stay, etc. This can provide valuable information for infrastructure and personnel aspects. The lack of a (near-) real-time monitoring system is also relevant within the COVID-19 pandemic (for intensive care) as pointed out by a KCE assessment report on the management of hospital surge capacity in the first wave of the COVID-19 pandemic in Belgium (KCE, 2020).

Amongst the interviewed stakeholders the notion exists that the next pandemic or health crisis, possibly due to climate change, may be something entirely different and require new types of actions from the sector. In order to be better prepared, several elements are raised (see before in section 6.2 and after in section 9.2.4). In order to account for an overflow and an issue reaching peak capacity in certain healthcare institutions, several stakeholders suggested that additional **flexibility between different lines** of the healthcare system as a whole can be useful. For example, when hospitals risk at being overrun, systems, protocols or guidelines should be in place which allow other health care institutions to cover this capacity issue. With systems in place to coordinate between first, second and third line, detrimental cascading effects flowing from one level/line to another can be prevented.

[1] https://www.benelux.int/files/2514/7730/9449/Rapport_DEF_EN.pdf

7. INFRASTRUCTURE OF HEALTHCARE SECTOR

In general, there is strong variation in the quality of infrastructure and technology throughout the health care systems and within healthcare institutions within the different levels. The age of the building is the main cause of this variation. Additionally, incentives in public versus private institutions may also differ in how protocols, guidelines etc. are approached. Infrastructure across the sector often includes old houses, hospitals or residences that require renovation (Anonymous, 2021a).

The main risk lies in finance-related aspects: on the one hand, having the correct financial incentives, and on the other hand, having sufficient financial resources to make the necessary changes. This latter element is one that all healthcare institutions are faced with.

7.1 QUALITY OF INDOOR ENVIRONMENT OF HEALTHCARE INFRASTRUCTURE

7.1.1 Current situation

The quality of the indoor environment refers to the quality of a building's environment in relation to the health and wellbeing of people spending time indoors. It covers various aspects such as noise, light, chemical and biological pollutants and thermal climate. The latter determines the thermal comfort and is influenced by temperature, humidity and drought. In section 5.1.3.3 we discussed various technologies that can be applied to create a high-quality indoor environment. In this section we focus on the indoor environment of healthcare infrastructure.

Indoor thermal comfort in healthcare infrastructures

In section 5.1.3.3 we described various passive and active cooling technologies to control indoor temperature.

Input from the stakeholders – both from interviews as well as survey results – learns that the sector is most aware of temperature-related risks, most infrastructure-measures are aiming at managing these risks. However there is a wide variety in the application of heat-controlling and cooling technologies depending on the size and age of the building. Also within a healthcare infrastructure there are strong differences between different parts or rooms of the building. Stakeholders also stressed that elderly individuals are often very sensitive to attempts of cooling (such as ventilation of air-conditioning). (Anonymous, 2021a, 2021b).

Across all healthcare institutions included in the survey, almost 90% is worried about indoor temperatures in the rooms of patients or residents during heat waves. Cooling techniques used in healthcare institutions include the opening of windows (59% of respondents) and standard air-conditioning (40% of respondents). This is complemented with external sunscreens (83% of respondents) or internal sunscreens (58%). Between institutions, one of the main differences is the use of standard air-conditioning, which is more prevalent in hospitals (2 in 3 hospitals) than in other types of healthcare institutions (1 in 3 other healthcare institutions). On the other hand, the opening of windows as a way of controlling temperature is less prevalent in hospitals (1 in 3 hospitals) compared to other types of healthcare institutions (2 in 3 other healthcare institutions). This inverse relationship is not unexpected since opening windows would offset the benefits of air-conditioning.

Indoor air quality in healthcare infrastructures

By analogy with indoor heat, indoor air quality is determined by the location of a building, the building envelope and materials used as well as the occupant's behavior.

It is important to refresh the indoor air regularly such that levels of air pollutants cannot build up and to prevent mould formation. As mentioned in section 5.4.1 elderly people, people with chronical circumstances (e.g. COPD) or other respiratory diseases are vulnerable to exposure to ozone.

Aeration and ventilation

Aeration is a short-term, intensive exchange of air between the indoor and outdoor environment, while in the case of ventilation it is a continuous process where air exchange is achieved naturally or mechanically driven.

In many private homes without a ventilation system, **aeration** by opening windows and/or doors in the morning and the evening is performed. This is not an option in the setting of a hospital or residential care home as it requires a manual intervention and the safety of patients/inhabitants cannot be guaranteed.

The disadvantage is that outdoor pollutants can enter the building through open (parts of) windows or doors. The levels of particulate matter follow the trends of outdoor concentration levels.

Natural ventilation is a continuous air flow to and from dwellings achieved by wind-driven and/or buoyancy-driven ventilation without mechanical systems e.g. by opening windows. Daytime ventilation is suitable only when indoor comfort can be experienced at outdoor air temperature. When it is too hot outside night-time ventilation is especially suitable and works best when night-time temperatures are substantially lower than daytime temperatures. A drawback from natural ventilation is a possible increase of indoor pollutant concentrations. Night-time ventilation might be difficult to achieve practically (WHO Regional Office for Europe, 2011).

Mechanical ventilation systems exist in different forms, the most advanced being system D where both the air supply to and removal of air from homes is performed mechanically. Mechanical ventilation systems type D are often accompanied by a heat exchanger (between incoming and outcoming air) and can hence serve as cooling (in summer) or heating (in winter). In the above-mentioned study by Hooyberghs et al. (2017) the effect of increased ventilation on cooling demand was studied. In one option increased ventilation during the day decreased the cooling demand but the costs stayed on the same level. In another scenario the nightly ventilation was kept to the daily rate (instead of a usual decrease), this gave rise to lower cooling demands during the day.

Mechanical ventilation systems use filter systems to keep outdoor pollutants out. The selection and maintenance of appropriate filters allows to filter coarse dust particles, insects, sands and hairs (lower filter class) and fine dust particles and pollen (higher filter class). Ozone, being an unstable molecule, cannot enter the building through the channels of the ventilation device. However, the intake of a mechanical ventilation system is best located at the least polluted location on the site, a place away from a busy road, parking lot, waste disposal area, smoking area, …

Results from the online survey data on the use of ventilation in rooms of patients or residents are shown in Figure 7-1. The results indicate that system D (and D+) are most prevalent across institutions, followed by system A and D. Compared to ventilation systems in the Flemish community, types A and C are more prevalent in the French community and in Brussels. There are no clear trends or significant differences between types of institutions (Anonymous, 2021b).

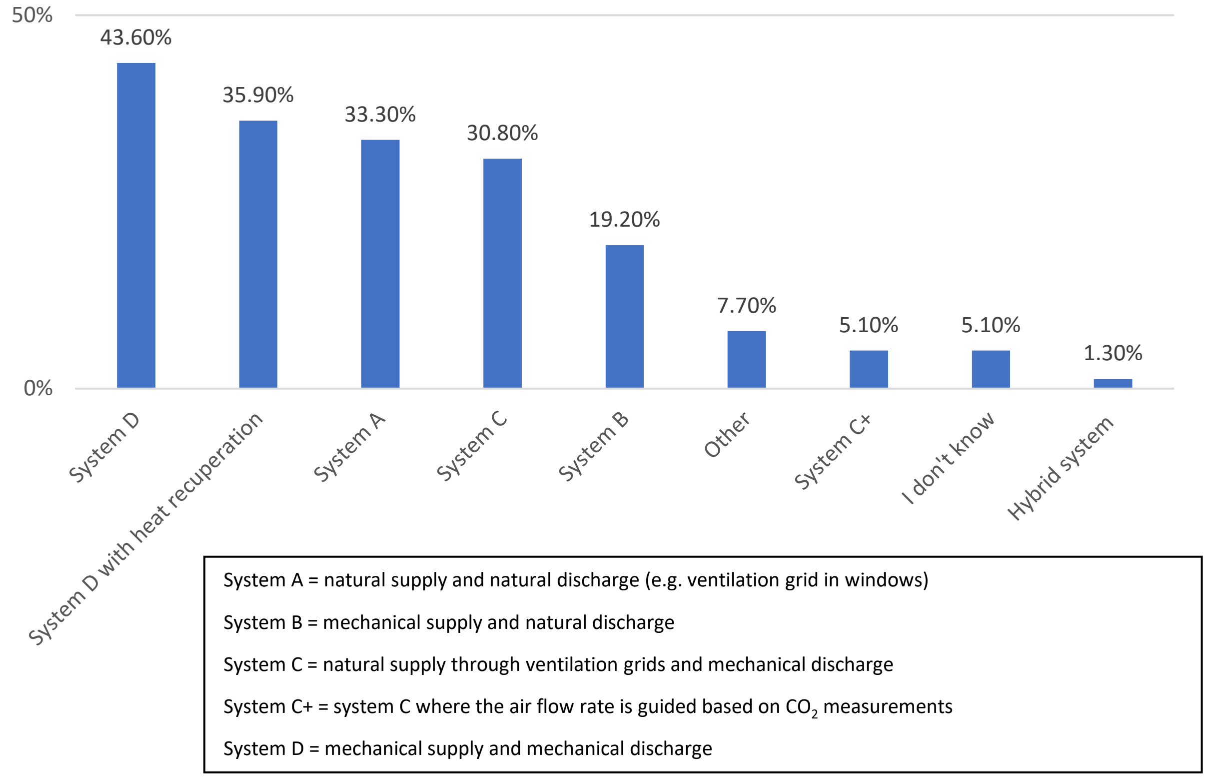

Figure 7-1. Overview of ventilation possibilities in rooms of patients or residents.

Air purification

Blocken and all (2021) used a combination of ventilation and air purification to remove aerosols from indoor sports centre. Air cleaning using plasma technology with activated carbon and electrostatic filters appears to be very effective. In combination with a ventilation system, they remove 80 to 90 percent of the aerosols from the air. Follow-up research will have to show whether this combination of air cleaning and ventilation also shows the same results with other technologies and in other environments, such as nursing homes, hospitals, … The researchers used two cleaning units, which in addition to traditional electrostatic, glass fibre and carbon filters, also use plasma technology. This relatively cheap technology cleans the air almost as efficiently as the HEPA filters used in hospitals and clean rooms.

A recent note discusses various air purification techniques in the framework of the reduction of COVID-19 virus transmission in the indoor environment[1].

7.1.2 Expected changes

As mentioned in section the outdoor climate will become hotter, drier and with possibly higher ozone and particulate matter concentrations. This all impacts the quality of the indoor environment.

Furthermore, it is expected that the energy consumption criteria of the EPB regulation will become stricter and that they will have to be applied in existing buildings (without retrofitting) as well. It is also expected that current norms for residential buildings might become compulsory for non-residential buildings.

[1] https://www.zorg-en-gezondheid.be/sites/default/files/atoms/files/Adviesvraag%20luchtzuivering-AZG-VITO_20201204.pdf

7.1.3 Current and planned measures

7.1.3.1 Ventilation

Various legislations exist on the quality of the indoor (working) environment, they describe ventilation conditions and CO_2 concentration guideline values.

As mentioned in section 5.1.3.3 the EPB regulation aims to reduce primary energy consumption and CO_2 emissions. In Belgium the implementation of the EPB is the responsibility of the regional governments. The EPB requirements for healthcare infrastructure (e.g. hospitals, residential care for elderly, day-care centres, psychiatric centres, revalidation centres) falls under the category "non-residential". The EPB legislation in all regions targets at an indoor air class IDA 3 or lower, expressed in $m^3/(h.pers)$. The standard NBN EN 13779 defines these classes and provides a direct classification of air quality based on measurements of CO_2 concentration. An average value of CO_2 concentration in outdoor air is usually between 350 and 450 ppm. With an outdoor concentration of 400 ppm, one must measure between 1,000 and 1,400 ppm to fall within the IDA 3 class of CO_2 concentrations.

At the national level, the "Codex over het welzijn op het werk"/"Code du Bien-être au travail"[1] is a royal decree (koninklijk besluit) and is hence the highest legislative framework. For buildings constructed or renovated after 1 January 2020, all spaces that meet the definition of workplaces must meet the requirements of a maximal CO_2-concentration of 900 ppm, or should be equipped with a ventilation flow of minimally 40 m^3/h per person. For buildings or parts of buildings constructed before that date, one must draw up an action plan with technical and/or organizational measures, together with a timetable for their implementation, to ensure that air quality is improved and the requirements are met in the short term.

For Wallonia the legislation mentioned above applies for healthcare facilities, there are no additional measures related to ventilation based on the nature of the persons accommodated or the care offered (AVIQ, personal communication June 2021).

For Flanders and Brussels a sectorial decree for the healthcare sector exists only for childcare facilities: $CO_2 < 1200$ ppm. There are recognition standards and licensing conditions for the indoor environment:

- Childcare facilities: healthy environment and sufficient ventilation;
- Care homes for people with disabilities: ensuring health;
- Hospitals: healthy environment, ventilation provided;
- Residential elderly care and homecare[2]: $CO_2 < 1200$ ppm.

There are also indoor quality guideline values formulated in The Flemish Indoor Environment Decree (Binnenmilieubesluit[3] 11/06/2004). For ozone the 8h-average concentration should not exceed 40 $\mu g/m^3$, the intervention value is 78 $\mu g/m^3$. For particulate matter PM2.5 the guidance value is 10 $\mu g/m^3$.

In the context of the COVID-pandemic the Superior Health Council issued recommendations on ventilation of buildings other than hospitals and care homes to reduce airborne transmission of SARS-CoV-2. They recommend at least 50 m^3 and preferably 80 m^3 of fresh air per person per hour, and to keep the CO_2 concentration as low as possible, and certainly below 800 ppm. They give expert opinion on the use of ventilation, air conditioning and air filtration systems (HGR, 2021). AZG issued additional advices on ventilation and aeration in order to create a healthy indoor environment for residential care

[1] https://werk.belgie.be/nl/themas/welzijn-op-het-werk

[2] https://www.zorg-en-gezondheid.be/sites/default/files/atoms/files/Toelichtingsnota%20infrastructuurvoorwaarden%20definitief%2014-02-2017%20%28002%29.pdf

[3] http://www.ejustice.just.fgov.be/cgi_loi/loi_l.pl?N=&sql=arrexec+contains+%272004061172%27+and+la+=+%27N%27&rech=1&language=nl&tri=dd+AS+RANK&value=&table_name=wet&cn=2004061172&caller=arrexec&fromtab=wet&la=N&cn_arrexec=2004061172&dt_arrexec=BESLUIT+VLAAMSE+REGERING

for elderly[1] and for daycare for elderly[2].

7.1.3.2 Heating and cooling

In the accreditation criteria for newly-built residential care centres and short-stay centres the Flemish[3] and Walloon[4] government has heat-related requirements:

- In the event of a heat wave, an air-conditioned room must be available that is large enough to accommodate all the residents whose accommodation is too hot;
- In order to achieve thermal comfort following steps must be taken (in this order):
  - careful design of the building envelope (orientation, sun blinds, sunproof glazing, sun blinds where necessary;
  - passive cooling system (top cooling, night ventilation, free cooling);
  - active cooling system in case of specific emergencies and in function of a comfort need of the occupants.

7.1.3.3 Funding mechanisms

For general care infrastructure in the Flemish Community the Flemish Infrastructure Fund for Person-related Matters (VIPA) of the Flemish Department of Welfare, Public Health and Family (WVG)[5] subsidizes the realization of sustainable, accessible and affordable care infrastructure. VIPA conducts energy audits, intervenes in the construction costs for new constructions as well as for retrofitting, as well as for the installation of energy-efficient cooling, heating and ventilation systems. Recently VIPA updated its sustainability criteria for sustainable building and renovating of health- and care-facilities. For the indoor environment there is a focus on passive cooling, ventilation and aeration. There are also criteria for site aspects, namely the promotion of biodiversity and the use of materials and green and blue infrastructure[6].

For public facilities in the French and German Community the UREBA[7] (Utilisation Rationnelle de l'Energie dans les Bâtiments) program of the SPW-Energie provides grants to support measures to improve the energy performance of the buildings. They provide energy audits, perform pre-feasibility studies and provide granting for the installation of energy-efficient systems related to heating, cooling and ventilation. For private healthcare facilities the AMURE[8] program of the SPW-Energie provides subsidies for energy audits.

7.1.4 Gaps between risks and current/planned measures - Adaptation actions and recommendations

Cooling techniques

Building regulations for newly built or retrofitted healthcare infrastructures, tend to focus on climate-mitigation measures (CO_2 reduction) by reducing energy consumption for heating (and cooling). However in order to create a healthy indoor environment this should be done in combination with ventilation and (preferably) passive cooling techniques (WHO Regional Office for Europe, 2021). However in hospital and residential care buildings where heat is generated by the presence of a lot of people (inhabitants and personnel), many electronic devices, etc., passive cooling techniques might

[1] https://www.zorg-en-gezondheid.be/binnenmilieu-in-wzc
[2] https://www.zorg-en-gezondheid.be/ventileren-en-verluchten-tegen-covid-19-in-de-thuiszorg
[3] https://www.zorg-en-gezondheid.be/sites/default/files/atoms/files/16-17044%20BVR%20wijz%20bijlage%20XII%20infrastructuurvoorwaarden.pdf
[4] http://sante.wallonie.be/sites/default/files/aines_reglementation.pdf
[5] https://www.departementwvg.be/vipa
[6] https://zorgwijzermagazine.be/milieu_preventie/transformatie-van-ziekenhuissite-naar-gezondheidscampus/
[7] https://energie.wallonie.be/fr/renovation-energetique-des-batiments-ureba.html?IDC=9484&IDD=83066
[8] https://energie.wallonie.be/fr/audits-et-etudes-amure.html?IDC=6374

not be sufficient. In several countries air-conditioning is becoming the most used technology for protection from overheating. In Belgium 3.1% of the population uses air conditioning, this share is considerably lower than the EU average of 10.8 % (data from 2007, Eurostat 2012). However the use of domestic air conditioning is increasing in recent years. Several EU countries made AC mandatory in various types of institutions, including nursing homes (WHO Regional Office for Europe, 2021).

Technical guidelines

Opinions among healthcare professionals differ when it comes to the need for better or more information on technical guidelines (Anonymous, 2021a). Mainly in the first line of care, there are often no possibilities available to request expert opinions on the optimal and future-proof ways to conceptualize buildings. Additionally, when guidelines are available, (small) health care facilities struggle to find ways of applying these guidelines to buildings in the context of healthcare. General and university hospitals on the other hand, point out that they are better able to either get this expert information or have experts in-house. Nevertheless, this information often regards mitigation (e.g. energy efficiency) and less attention is paid to adaptation measures (Anonymous, 2021a).

As detailed before and below, green and blue infrastructures are adaptation measures concerning heat, flooding, but also as a means of health promotion. The idea of the use of green and blue in a hospital or healthcare setting is welcomed by many stakeholders, with limited financing posed as the main barrier.

The use of green and blue infrastructure needs to be considered with care since they can pose health hazards to patients or residents as well. For example, residents in psychiatric hospitals or facilities may express more risky behaviour, several health care facilities also note a risk of trees falling on the buildings. (Anonymous, 2021b).

7.2 INFRASTRUCTURE DAMAGE AND MAINTENANCE COSTS

7.2.1 Current situation

Climate-related infrastructure damage can be expected from different hazards. Floods, windstorms, hail and drought are identified as the most impactful climate events for Belgian insurers (NBB, 2019).

7.2.1.1 Heat and drought

Since 2017, we have experienced extremely hot and dry summers in Belgium. Heat exposure can reduce the life time of surfaces (e.g. through surface cracks) and enhances the probability of wildfires damaging infrastructure. Furthermore, higher temperatures cause more evaporation of soil moisture, in combination with less rainfall during summer and insufficient water infiltration the soil is drying. The lower soil moisture conditions cause soil types such as clay and loam to shrink. This can lead to subsidence, affecting the stability of building foundations and causing cracks and fissures in the buildings. In Flanders there has been recently media attention for this problem[1], this problem also persists in Wallonia but very locally.

7.2.1.2 Flooding

Intense rain fall can lead to pluvial flooding especially in densely-built urban areas where there are little water infiltration possibilities. Low-lying areas along waterways are particularly vulnerable to fluvial flooding. Cities are particularly vulnerable to flooding from heavy precipitation events owing to the large share of impervious surfaces that inhibits penetration of water into the soil and converts incoming precipitation into runoff and overland flow. Risk of pluvial flooding is also influenced by the capacity and state of drainage and sewage systems in cities (EEA, 2020b). In hilly landscapes, heavy

[1] https://www.vrt.be/vrtnws/nl/2021/03/08/droog-vlaanderen/

and/or persistent precipitation events combined with surface water run-off can induce muddy floods and an increase in the risk of landslides.

7.2.1.3 Extreme storms

Extreme storms that are characterized by high wind speeds can cause damage on infrastructure by blowing away infrastructure elements or by trees/vegetation.

7.2.1.4 Wildfires

The prevalence of wildfires in Belgium is rather limited. The annual burnt area rarely exceeds 40 ha, but depending on the meteorological conditions relatively large areas, in a Belgian context, can be affected. Unfortunately, these fires often occur in biologically valuable nature areas. A recent study by Depicker et al. (2020) shows that fire risk is the highest during dry months of March/April and the hot summers in July and August mostly due to the rainfall patterns. Belgium's forest fires amount to about 66% of declared fires, the provinces that have the largest relative areas with a high or very high wildfire risk are Limburg and Antwerp (Depicker et al., 2020).

7.2.1.5 Maintenance costs

Related to maintenance costs are the costs for renovations to older buildings: several stakeholders point out that lack of a long-term vision on adaptation measures leads to 'ad-hoc' infrastructure investments to patch up or improve on specific elements. Nevertheless, these stakeholders are convinced that this is not a financially optimal way of working nor will it ensure sustainable buildings in the long run. This lack of a strategic plan of healthcare in the long run and which infrastructure is required to reach these goals is an important risk (Anonymous, 2021a). However, health care facilities aiming to implement more a long term vision and ambitious renovations, run into issues with financing, causing a slower pace of implementation of adaptation measures than preferred (Anonymous, 2021a, 2021b).

7.2.2 Expected changes

Forzieri et al. (2018) studied the impacts of climate extremes on critical infrastructures from different sectors (energy, transport, industry, social sectors including health and education subsectors) in Europe. In this study simulated data on exposure to different hazards with damage information derived from disaster databases was combined. The authors found that, whereas current hazard damage to the critical infrastructures relates mostly to river floods (44%) and windstorms (27%), the proportions of drought and heatwaves will rise strongly, to account for nearly 90% of climate hazard damage by the end of the century (vs 12% in the baseline period). This suggests that impacts of climate extremes could change not only in terms of the magnitude of damage, but also in their typologies. This trend is stronger for the South of Europe than for the North, and Forzieri et al. (2018) state that 'river and coastal floods will remain the most critical hazard in many floodplains and coastal stretches of western, central and eastern Europe'. Nevertheless, by the end of the century heat and droughts become an important cause of climate-related damages in those countries too. In the online survey, health care facilities were asked about the main concerns they have related to infrastructure damage due to extreme weather conditions. The top 3 concerns are interruptions in energy provision, transmission or distribution (1 in 2 respondents), followed by damage to data networks and IT infrastructure (1 in 3), as well as issues with other types of supply (e.g. food, water) (1 in 4 respondents). These responses are consistent across the communities in Belgium. Additionally, when given the option to specify additional risks that were not among the pre-determined options in the survey, almost 10% of institutions note concerns about flooding in their buildings. Aside from this, several cite a general concern of deterioration of buildings due to their age and maturity (Anonymous, 2021a, 2021b).

7.2.2.1 Flooding

Due to climate change with wetter winters and more intense precipitation, both coastal, pluvial and fluvial floods may occur more often, even in places that have not been flooded so far. It is hence possible that both the inundation area and the inundation depth will increase if no further measures are being taken.

The VMM-Klimaatportaal[1] for the Flemish Region shows for the current climate as well as for high-impact scenarios for 2030, 2050 and 2100 flooding maps. The floodable area in Flanders (under a high impact scenario) would increase by 77% towards the year 2100, and the proportion of vulnerable institutions affected by 'dangerous' flooding by rivers and streams would more than double.

For the Walloon Region, it has been estimated that as a result of climate change the floodable area would increase by 50% and the number of people affected by 183% (De Ridder et al., 2020). In the recently developed flood risk management plans (Plan de Gestion des Risques Inondations, PGRI), climate change effects have been included in the creation of the flood hazard maps. Currently these maps are still under consultation and not yet publicly available[2]. The Geoportal of Wallonia[3] maps vulnerable establishments but this map has not been combined with scenario-based flood-related maps.

For the Brussels region no flooding hazard maps, that take climate change effects into account, are available.

The combination of flooding with a dry, and hence more erodible, soil will increase the risk for mud floods and landslides.

As mentioned in the previous sections, respondents in the online survey point out risks of flooding as an important concern regarding infrastructure damage. During interviews with stakeholders in the sector, it was also indicated that this flooding may cause issues with water pollution for which they are insufficiently prepared (Anonymous, 2021a, 2021b).

7.2.2.2 Drought

Extreme drought may occur more frequently and more intensely in the future, leading to lower levels of groundwater and to more erodible soil conditions.

The aforementioned VMM-Klimaatportaal shows for high-impact scenarios for 2030, 2050 and 2100 maps with the drought sensitivity of the soil in Flanders. For the other regions no climate projections related to drought are available.

7.2.2.3 Wildfire

Climate change scenarios indicate the more frequent occurrence of extreme heat in combination with drought. The combination of drought and strong winds can trigger natural fires. The number (or extent) of areas at risk is not expected to increase, but climate effects will lead to a prolongation or increase in critical periods.

Figure 7-2 shows weather-driven fire danger for the present climate and for projected climate conditions under two emissions scenarios, as calculated in the JRC PESETA III project[4] and provided by EEA. These projections show marked increases in fire danger in most European regions, changes are more pronounced for higher than for lower emission scenarios. For Belgium the "change for 2 °C global warming" climate scenario gives for most areas in Belgium a 5-10 % increase in fire weather index, while the 'change for high emissions" an increase between 20-30 %.

[1] https://klimaat.vmm.be/nl/web/guest/klimaatverandering-in-detail
[2] http://environnement.wallonie.be/enquetepublique-plandegestion-inondation/
[3] https://geoportail.wallonie.be/home.html
[4] https://ec.europa.eu/jrc/en/peseta-iii

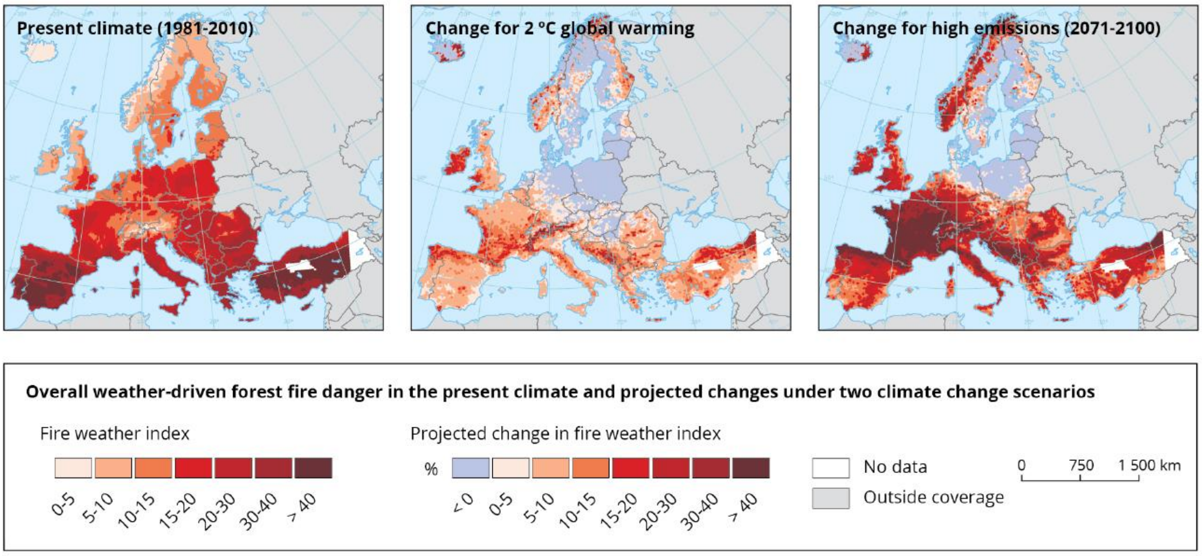

Figure 7-2. Weather-driven fire risk for current and predicted climate in Europe. The Canadian Fire Weather Index (FWI) is shown for present climate and for predicted climate (2071-2100) under two climate change scenarios (2 C° and high emissions). The FWI coverts a relative fire potential in a uniform numerical rating combining information from relative humidity, precipitation values, windspeed and local temperature. Source: https://www.eea.europa.eu/data-and-maps/indicators/forest-fire-danger-3/assessment.

7.2.3 Current and planned measures

7.2.3.1 General

The website R!SK-iNFO.be[1] of the federal government aims to inform and prepare the general public for various types of hazards including natural hazards such as storms, floods, heat waves, cold weather, woodfire, drought. The website contains practical information on what to do before, during, after a hazard and provides links to relevant authorities.

Defense intervenes in the national crisis management in case of natural disasters to reinforce the civil capacities (fire brigade, civil protection, police, etc.). E.g. they support in providing helicopters for extinguishing forest and heath fires which are difficult to reach.

7.2.3.2 Flooding

7.2.3.2.1 Data availability

The Water Framework Directive (2000/60/EC) establishes a legal framework to protect and restore water quality and ensure the sustainable use of water in the long-term. Its main goal is to set specific deadlines to achieve good status of the water system (both surface water and groundwater).

For the regions decrees on integrated water policy represent the juridical implementation of this directive in regional law.

The Floods Directive (2007/60/EC) establishes a legal framework to assess and manage flood risks to mitigate the negative impacts that floods may pose to human, environment, cultural heritage and economy. Within the context of this directive, member states must report on flood hazard and flood risk and must publish corresponding and publicly available maps. These maps identify areas with a high, medium and low likelihood of flooding and indicate expected water depths. ('Medium' being defined as an event with a probability of occurrence of 1/100. The low and high likelihoods have no corresponding probability in the Directive.) In the areas identified as being at risk the number of inhabitants potentially at risk, the economic activity and the environmental damage potential have to be indicated. It should be noted that the hazard and risk maps discussed here give probabilities based on the present climate conditions. In Belgium, each of the three regions has developed its own web-based portal where the maps prepared according to the Floods Directive can be consulted: Wallonia[1], Flanders[2], Brussels[3].

A flood warning and forecasting system is operational in Wallonia[4] and Flanders[5], they combine measured water levels and flood forecast models.
Belgium is involved in the European Emergency Management Service (EFAS)[6] within the Copernicus programme, this service brings together national data of forecast models on a European scale. This action contributes to the realization of the action "enhanced collaboration between member states for crisis management in case of natural disasters" of the federal contribution of the NAP.

7.2.3.2.2 Measures at local and regional level

At the local level different strategies are to **avoid run-off of rainwater** by collecting, buffering and infiltrating it: installation of green roofs, planting of trees, increasing the surface of non-paved and permeable paved surfaces (e.g. parking areas). For the infiltration, one can exploit natural or manmade relief: bring water to lower areas and give it time to seep into the soil (infiltration pits, infiltration strips, infiltration trenches, wadis, etc.).

The majority of Belgian cities and municipalities disposes of an energy and climate plan as detailed in section 4.2.4. Local measures against flooding take a prominent place in all plans. All regional adaptation plans (VAP, PWEC, PNEC-BCR) describe measures in order to reduce the risk of flood and water shortage as much as possible. All plans mention measures in order to raise awareness of water as a precious resource.

For healthcare facilities in the Flemish Community VIPA (see section 7.1.3) recently updated its sustainability criteria for sustainable building and renovating of health- and care-facilities. One of the aspects is related to the building site, namely that it should be located in a flood-prone area.

With respect to **mud streams** the unit Gestion Intégrée Sol-Erosion-Ruisellement (GISER) of SPW-Agriculture, Ressources naturelles et Environnement provides advice and guidance to reduce the risk of erosion and run-off in agricultural areas, as this can cause damage to the agricultural land and neighbouring houses. The PWEC mentions that the GISER-unit works with communes and farmers to combat erosion, landslides and mud streams. They provide practical advice for public managers (of municipalities, regional and provincial administrations) and farmers of rural areas in order to use nature-based solutions (NBS) to temporarily store run-off water and/or reduce the speed of flow. The list of possibilities presented[7] is open and evolving, depending on the experience that is being built in Wallonia thanks to the dynamics of certain municipalities, river contracts, provincial technical services, etc. In order to assess the situation of each urban development project with regard to concentrated runoff, the project developer must take into account local elements such as relief, infrastructure, neighboring properties and their buildings, or the existence of previous flooding problems[8].

At the **regional level** the VAP mentions the importance of large green spaces such as urban forests and natural river valleys and buffer basins that absorb (winter) water flooding from rivers. The Flemish government is working with local authorities and local stakeholders on a so-called climate buffer program. This program creates large-scale natural areas and green-blue networks to protect urban

[1] https://inondations.wallonie.be/home/urbanisme/cartes-inondations/carte-alea-inondation.html
[2] https://www.waterinfo.be/Watertoets
[3] https://leefmilieu.brussels/themas/water/water-brussel/regenwater-en-overstromingen/overstromingskaarten-voor-het-brussels
[4] http://voies-hydrauliques.wallonie.be/opencms/opencms/fr/hydro/Actuelle/crue/index.html
[5] https://www.waterinfo.be/Themas#item=overstroming/48u%20vooruit
[6] https://www.efas.eu/
[7] https://www.giser.be/wp-content/uploads/2016/10/Giser-brochure-FINAL-partie1.pdf
[8] https://www.giser.be/wp-content/uploads/2018/12/Broch.-RisqueInondPermisDemandeur-Web.page_.pdf

areas from flooding. This program is coordinated by the Coordination Commission Integrated Water Policy[1]. In Brussels the regional plan for sustainable development mapped the green network[2]. SPW-Département de la nature et des forêts provides a funding to both increase urban green as well as to realize green-blue networks[3].

7.2.3.3 Drought

All regions take measures to reduce water consumption by households, agriculture and industry and other sectors. Information campaigns are also in place. In periods of severe droughts restrictions on the use of water and water capture bans can be declared. More information is available online for Brussels[4], Flanders[5], Wallonia[6].

7.2.3.3.1 Water reuse

As mentioned in section 5.3.4.6, one of the five strategies of the VAP concerns circular economy, one of the aspects is the reuse of water. The Flemish Government's vision paper "Visie 2050 - Een langetermijnstrategie voor Vlaanderen" puts a robust water system first. For the Brussels region, in the PACE-BCR plan, several actions are taken to concretize the measure to adapt water management. Reference is made to concrete actions that can be taken by citizens, such as reuse of rainwater at home, installation of rainwater tanks. In the Walloon plans there is no mentioning of water reuse.

7.2.3.4 Wildfire

7.2.3.4.1 Data availability

The Flemish Agency for Nature and Forest issues wildfire warnings with a colour code per Flemish province[7], this system is also in place for the Hautes Fagnes[8]. Colour code green means little danger of fire, yellow indicates an increasing risk of wildfire. When the risk of natural fires is assigned the colour code orange or red, any additional risk of fire because of making fire or smoking in nature and forest areas must be avoided. This imposes a temporary ban on making fire and smoking in the forests and several nature reserves. In case of colour code red a walking ban is in place. At the provincial and municipality level fire bans can be imposed too.

Belgium is involved in the European Forest Fire Information System (EFFIS)[9] within the EU Copernicus programme. They provide a viewer of the current situation, a long-term monthly and seasonal forecast of temperature and rainfall anomalies that are expected to prevail over Europe. Belgium's participation in this system contributes to the realization of the action "enhanced collaboration between member states for crisis management in case of natural disasters" of the federal contribution of the NAP.

There is no public geographical data available on the wildfire ignition probability for Belgium. Depicker et al. (2020) constructed a wildfire ignition map shown in Figure 7-3. They used information on soil type, land cover and land use. The land use map used distinguished between three classes: (i) military domains (1.18 %), (ii) nature areas (25.43 %), and (iii) the remaining land use classes (73.39 %). It appears that most wildfire-prone areas in Belgium are located in heathland where military exercises are held.

[1] https://www.integraalwaterbeleid.be/
[2] https://environnement.brussels/lenvironnement-etat-des-lieux/rapports-sur-letat-de-lenvironnement/rapport-2011-2014/espaces-verts-5?_ga=2.171540512.1261943230.1624455413-1827081857.1621522911
[3] http://biodiversite.wallonie.be/fr/30-04-2021-appel-a-projets-parcs-en-milieu-urbain.html?IDD=6579&IDC=3772
[4] https://environnement.brussels/thematiques/espaces-verts-et-biodiversite/mon-jardin/ma-consommation-deau
[5] https://www.vlaanderen.be/droogtemaatregelen
[6] https://www.wallonie.be/fr/actualites/quel-est-letat-de-la-secheresse-en-wallonie
[7] https://www.natuurenbos.be/waarschuwingen
[8] https://www.hautesfagnes.be/
[9] https://effis.jrc.ec.europa.eu/

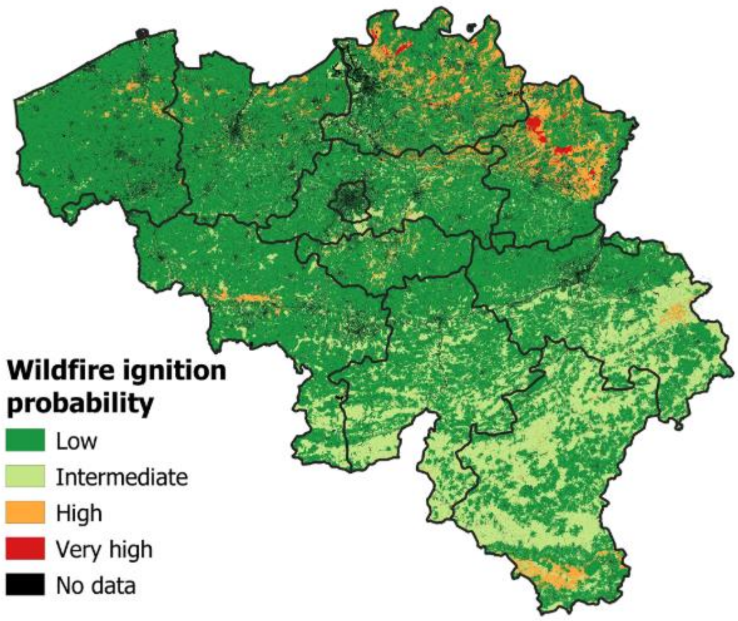

Figure 7-3. Ignition probability map constructed with land cover class, soil type and land use class. Source: Depicker et al. (2020)*.*

7.2.3.4.2 Preventive measures

All adaptation plans aim to ensure that climate-related incidents and disasters such as wildfires (and floods) occur less frequently, or at least to minimize damage to people and nature

The Flemish NECP mentions that guidelines have been developed for climate-adaptive management of the Agency for Nature and Forests, with a focus on preventing natural fires (both in forests and more broadly, such as on heathland) through good monitoring and follow-up.

The Walloon region has developed, in the framework of the PACE, several awareness-raising campaigns on fire control, both for private individuals and professionals, which should contribute to public awareness.

7.2.3.4.3 Emergency services

After the large-scale natural fires in 2011, several measures were taken concerning damage inventory and the replacement of defective equipment, the improvement of the practical organization of useful supply (water, food, fuel, etc.), operational communication (including better coverage of the Astrid network). However no National Wildfire Action Plan has been set up so far, no wildfire risk map (including both fire ignition and propagation) for strategic nor operational use is available. The National Geographic Institute (NGI) has developed a uniform and shared cartography for emergency services across Belgium, however this was mainly related to the common use of and consistency between underlying data[1].

[1] https://www.ngi.be/website/case/cartografie-voor-natuurbranden/

7.2.4 Gaps between risks and current/planned measures - Adaptation actions and recommendations

7.2.4.1 Floods

7.2.4.1.1 Data availability

Flood hazard: monitoring and surveillance of current situation and climate projections

Concerning the risk of pluvial or fluvial flooding, detailed flood hazard maps indicating the location and characteristics (inundation area, maximum inundation depth) of the flooded zones, are not generally available. These flood maps are not available nor for the current situation, nor for future scenarios. Within the EU-H2020 project "Climate-fit.city – Pan-European urban climate service"[1] a pluvial hazard map has been developed for urban flash floods, the demo project was set up for the city of Antwerp.

A pluvial hazard map has been developed for urban flash floods, the demo project was set up for the Emergency Planning unit of the city of Antwerp. The tool identifies risk zones, including information on inundation depths, in the city for different (current and future) pluvial flood scenario's. Precipitation data (intensity, duration and frequency) was derived from high-resolution climate models that are run under different RCP scenarios. The identification of inundation zones, together with information on the inundation depth, requires the coupling of hydrological and inundation models of the Hydraulics Department of University of Leuven[2]. The required input data of these models includes the aforementioned precipitation data (intensity, duration and frequency) as well as local data on topography, land cover, buildings, drainage systems, river systems, sewage systems, surface draining systems, infiltration and roughness zones, etc. The availability of good-quality hydraulic data is essential for accurate modelling.

Flood impact mapping of vulnerable infrastructure

In a further step the tool quantifies the consequence of pluvial inundations by combining the information on the risk zones with the location of essential and vulnerable infrastructure (hospitals, strategic buildings, underground public transport stations, electricity distribution hubs, elderly homes…) as well as vulnerable segments of the city population.

For the hospitals all systems, situated on the ground floor as well as underground, and hence vulnerable for flooding were identified and located: energy transformer cabins, emergency power supply, water supply, heating, ventilation, air conditioning or cooling (HVAC)-systems, emergency entrance, accessibility ambulance, medical gases, medical waste storage, ventilation holes, cellar holes, underground entrance, etc. This work is very labour intensive and requires a good knowledge of the operation and environment of the hospital.

The tool allows to give a visual overview of the impacted infrastructure for the scenario of choice. Figure 7-4 gives an overview of the viewing possibilities. In the left figure the inundation depth of the streets can be seen together with the systems at the hospital property that are vulnerable for flooding. The right panel gives a detailed overview for the number of flooded parts for different pluvial scenario's in the current situation and in 2050. Every line shows for a certain hospital system the number of systems/locations that are likely to be flooded for different pluvial scenario's. The line with the red block shows that in 7 scenario's there is no problem with the ambulance entrance/exit, but in the T100_2050 scenario it will become blocked by inundation. The yellow line shows that for another hospital there are 6 systems (in the group of ventilation holes, cellar holes, underground entrance) that are vulnerable for flooding in all scenario's.

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1 https://climate-fit.city/

2 https://bwk.kuleuven.be/hydr

Object	T5 huidig	T5 2050	T20 huidig	T20 2050	T50 huidig	T50 2050	T100 huidig	T100 20
Sint-Vincentius Ziekenhuis (GZA)								
hoogspanningscabine	0	0	0	0	0	0	0	
ingang spoed	0	0	0	0	0	0	0	0
noodaggregaat	0	0	0	0	0	0	0	0
stookplaats of HVAC	0	0	0	0	0	0	0	0
toegang MUG	0	0	0	0	0	0	0	[illegible]
ventilatierooster, keldergat, ondergrondse ingang	0	0	0	0	0	0	0	0
Stuivenberg Ziekenhuis (ZNA)								
hoogspanningscabine	0	0	0	0	0	0	0	0
ingang spoed	0	0	0	0	0	0	0	0
noodaggregaat	0	0	0	0	0	0	0	0
stookplaats of HVAC	0	0	0	0	0	0	0	0
toegang MUG	0	0	0	0	0	0	0	0
ventilatierooster, keldergat, ondergrondse ingang	6	6	6	6	6	6	6	6
Elisabeth Ziekenhuis (ZNA)								
hoogspanningscabine	0	0	0	0	0	0	0	0
ingang spoed	0	0	0	0	0	0	0	0
noodaggregaat	0	0	0	0	0	0	0	0
stookplaats of HVAC	0	0	0	0	0	0	0	0
toegang MUG	0	0	0	0	0	0	0	0
ventilatierooster, keldergat, ondergrondse ingang	0	0	0	0	0	0	0	0

Figure 7-4 Results from the Climate-fit.city flood impact mapping of hospital infrastructure in Antwerp. *Left: Vincentius Hospital Antwerp and its vulnerable locations, in relation to T100, current climate. Right: Identification of likelihood of flooding for different systems in three hospitals in the Antwerp city centre.*

Currently the city of Antwerp participates in the Cutler H2020 research project. They focus on the development of structural urban adaptation by means of a storm water plan in Antwerp using an evidence-driven approach enabled by big data.

7.2.4.2 Drought

The drought of recent years has led to an increase in the demand for groundwater wells. The drilling of a well needs to be reported to the regional authorities responsible for water policy, in case of extensive water pumping one also needs to apply for a permit[1]. However, one suspects there are many illegal groundwater wells exploited resulting in massive pumping of groundwater. Hence a better monitoring of groundwater pumping is required.

7.2.4.3 Wildfire

Concerning the risk of wildfire, detailed wildfire hazard maps indicating the location and characteristics of the zones at danger as well as forecast systems, are not generally available. The setup of this type of mapping requires data on the fire ignition probability (already performed, see section 7.2.3.4.1) as well as on the fire propagation probability. The latter requires knowledge on the available fuel type, fuel moisture, topography and meteorological data (wind, temperature) (San-Miguel-Ayanz et al., 2018).

[1] https://www.vlaanderen.be/melding-en-vergunning-voor-gebruik-van-grondwater

7.2.4.4 Investments in healthcare sector

In order to avoid ad-hoc investments which can improve conditions in the short run, but not the long run, stakeholders point out the need for a long-term vision on climate adaptation measures for the healthcare sector (Anonymous, 2021a). This long-term vision will have to be supported by sufficient financial means or incentives in order to allow for its implementation.

8. ENERGY AND IT-INFRASTRUCTURE IN HEALTHCARE SECTOR

8.1 ENERGY INFRASTRUCTURE

8.1.1 Current situation

The healthcare sector is a huge energy consumer, responsible for approximately 5.5 % of the CO_2-emissions in Belgium, according to the Health Care Without Harm country report for Belgium[1]. Even though numerous energy-saving measures have been taken in recent years, the energy consumption levels remain high because of an increasing use of electronic medical devices. Reliable power supply is a requirement in hospitals and for critical medical treatment: intensive care equipment, devices for medical imaging and clinical laboratory services.

Electrical power supply to a healthcare facility is provided via power lines to a utility power substation located mostly off facility grounds. At the facility transformers reduce the incoming voltage to the desired voltages needed for different applications.

Brown-outs, the instantaneous loss of the desired voltage level, can cause sensitive electronic devices such as computers, frequency converters and magnetic switches, to fail. The installation of an uninterruptable power supply (UPS)-system in hospitals assures a constant voltage level. A power system management platform allows for continuous monitoring, automatic notification of events, integration into the hospital's building management system.

In case of a longer utility power failure hospitals have a back-up power generation system in place, mostly consisting of diesel generator(s) which can feed essential loads throughout the facility.

8.1.2 Expected changes

Climate change can have a negative effect on different aspects of the energy sector: production, transport and distribution and use. The NECP states that by 2030 Belgium aims to cover a 37.4% share of its electricity consumption from renewable energy sources.

Production plants

Centralized production plants include nuclear power plants as well as thermal power plants, fueled by gas, oil, coal, biogas and biomass. Weather conditions can affect the thermal efficiency and the load of these power plants (up to their shutdown) via several factors. An estimate of the combined summer heatwave and drought of 2003 in Europe shows a decrease of about 5% of thermoelectric power utilization rates (Van Vliet et al., 2016). Future trends also show a decrease of the usable water capacity of thermoelectric power up to 15% in Europe by 2050 (Dumitraşcu et al., 2019; van Vliet et al., 2016).

Decentralized electricity production covers all types of renewable electricity production, meaning wind (onshore and offshore), hydro, solar, and biomass (solid and liquid). Belgium has little hydropower due to its lack of relief, which is why its power capacity is mainly concentrated in Wallonia. Hydroelectricity's production could be affected by climate change through change in river flow regime, evaporation and dam safety (ICEDD, 2014). However, due to changes in precipitation, the hydroelectric production could rise during the winter and decrease in the summer, especially during droughts, when the hydric stress will be felt the most. This effect will be hard to counter because of the limited storage capacity (ICEDD, 2014). Wind turbines are affected by variation in wind intensity. The power delivered by a wind turbine changes as the third power of wind speed until it has to be stopped for damage control: the cut-in wind speed is around 3 m/s, and wind turbines are shut off above a cut-out speed of around 20 to 25 m/s (Dumitraşcu et al., 2019). Solar production from photovoltaic cells is also affected by weather patterns, namely sun radiation, cloud cover, wind and temperature. Photovoltaic cells lose roughly 0.4 - 0.5% of production per degree of warming, which

[1] https://healthcareclimateaction.org/fact-sheets/48

seems marginal compared to the rapid technical advancements of the industry (ICEDD, 2014). Cloud cover is a crucial variable, which directly influences solar production; sunshine drop might lead to a drop of 3% to 5% in our region which includes Belgium, Holland and Germany (Jerez et al., 2015).

Electricity transport and distribution efficiency

Elia is in charge of the electricity transportation in Belgium via its high voltage (HV) network of 380 kV, 220 kV and 150 kV. According to ground measurements, losses in the past five years have varied between 1.2% and 1.45%. In the year 2018, Elia estimates its losses to be 717.2 GWh (Elia, 2018). Those losses correspond to heat loss from natural and artificial cooling. In practice, while losses due to electricity transportation and transformation vary with the square of the current being transported. These loses calculated by Elia do not include loses on the distribution side, in the medium voltage (MV) and low voltage (LV) networks.

Electricity transportation and distribution are affected by air and ground temperatures. The warmer the ambient temperature the higher the loss of power both for the transport (HV), the distribution (MV and LV), and the transformation (voltage reduction) between networks. Electric resistivity is (in first approximation) affected linearly by the temperature of its cables which will mainly be a function of the current load that is being transported under a defined voltage and cable section. Air and ground temperature also play a role in dissipating the cables' temperature. A rule of thumb made for England in a climate change perspective states that for every degree rise, less than 1% of transport and distribution losses are to be expected (ICEDD, 2014). In the US, a study shows that under RCP climate change scenarios, the increase in ambient air temperature during the summer months may result in decreased transmission capacity of 1.9% to 5.8%, for the period 2040-2060 and relative to 1990-2020 (see Figure 3-42). At the same time, during those summer months the demand may rise from 4.2 to 15.0% due to higher air conditioning needs (Bartos et al., 2016).

There is a general heat risk for sensitive electronic components used in substations or transformers, both in general as well as specific hospital-related transformers the risk for failing increases with temperature.

Energy demand

The largest economic impacts are found in the field of energy demand. It is expected that milder winters will induce a reduced heating demand. Conversely, hotter summers will induce an increased demand for cooling energy. Overall, there is a large tendency for these two figures to compensate. With the expected increase in energy demand for cooling in hot summer months, the risk of black outs increases.

8.1.3 Current and planned measures

8.1.3.1 Healthcare sector

As mentioned in section 7.1.3 there are different organizations (VIPA for Flemish Community, UREBA & AMURE for French and German Communities) that provide services for the healthcare sector to increase their energy efficiency. They provide energy audits, pre-feasibility studies and provide granting for the installation of energy-efficient systems related to heating, cooling and ventilation.

For hospital setting, in case of an electricity black-out, there should be intrinsic redundancy to overcome limited shortages and the potential concurrent lapses in energy delivering services. The HEP (detailed in section 3.4) indicates the total power requirement for emergency power together with the power capacity of the back-up generators.

8.1.3.2 Energy sector

ENOVER is a consultation group aiming to strengthen cooperation on energy between the federal and regional governments and to ensure the link with the European Commission, they have working groups focusing on mitigation and adaptation the energy sector.

ENOVER contributes to the National Energy and Climate Plan 2021-2030 that focuses on mitigation measures, but sometimes co-benefits for adaptation emerge. Concerning energy security, the Belgian NECP states that maintaining high levels of security of supply is a priority in the ongoing transformation of the energy system, with an objective of 37.4% renewable electricity and increasing shares of domestic renewable energy of 17.5%. In order to incorporate these energy sources in the existing electricity network, a resilient electricity network needs to be realized in order to guarantee security of energy supply. The plan takes action concerning the continuous monitoring of the national security of supply situation considering developments in connected countries, the creation of robust networks with high interconnection rate for electricity, the plan makes adequate links with the emergency plans for gas, electricity and oil, provided for by applicable sectorial rules. However the national NECP lacks detailed information on further measures and investments in electricity storage, demand-response and other flexibility measures (EC, 2020).

Belgium is involved in various transnational cooperation projects focusing on the exchange of knowledge, experiences and good practices. Within the cross-border collaboration between Benelux countries, climate adaptation cooperation started in 2014, various conferences and workshops focused on adaptation in risk assessment, health, energy, transport & mobility (Benelux, 2019). Concerning energy, it appears that between network operators in the different countries mutual knowledge and technical consultation is quite good, but that no comparable consultation structure exists between the energy competent authorities. E.g. it is not clear whether all network operators will follow the same strategy in crisis situations, which measures will be taken to reduce consumption. There is a need for better information exchange and regular cross-border consultation to create a more coherent approach across borders. Most cross-border agreements within the Benelux are based on a reactive approach, while there should be more focus on prevention (Benelux, 2019). Belgium is partner of the Pentalateral Energy Forum, a framework for regional energy cooperation in Central Western Europe (also including the Netherlands, Luxembourg, France, Germany, Austria and Switzerland) towards improved electricity market integration and security of supply[1]. In 2018 an exercise on emergency planning and crisis management for the energy sector was held. The exercise confirmed the interdependency between the countries, national decisions can impact the internal electricity market, neighbouring countries and the entire region. Various lacks were identified on e.g. transparency in the preparation phase and during a crisis and the lack of coordination mechanisms for government decisions and communications. The priorities in 2021 focus on the role of hydrogen in view of reaching climate neutrality and the need of cross-border infrastructure. This transnational cooperation on adaptation was one of the objectives of the NAP.

The National Adaptation Plan 2017-2020 includes energy as one of the priority areas, however so far only two measures (a constant monitoring of the electricity supply and demand and load shedding strategies) are in place as mentioned in the national climate change impact, vulnerability and risk assessment (Technum, 2013). The evaluation of the impact of climate change on the security of the energy supply and the energy transport and distribution infrastructures, as foreseen in the NAP2017-2020 (measure 6), was not carried out (NCN, 2021).

Concerning the load shedding plans, Elia, the Belgian transmission system operator, has designed the disconnection plan in such a way that it can be activated manually in the event of a shortage[2]. As hospitals are classified as critical infrastructure (see also section 9.1.1) they have priority energy supply. However this is not the case for psychiatric hospitals, residential elderly care, revalidation

[1] https://www.benelux.int/nl/samenwerking/pentalateral-energy-forum
[2] https://www.fluvius.be/nl/thema/energieschaarste

centres, centres for persons with disabilities etc.

The evaluation report of the NAP mentions that the energy sector will further assess adaptation strategies in the framework of the European Green Deal (NCN, 2021).

8.1.4 Gaps between risks and current/planned measures - Adaptation actions and recommendations

8.1.4.1 Crisis management

The HEP (detailed in section 3.4) mentions the capacity of diesel generators, but from the survey it follows that only 72% of the HEPs includes aspects related to fuel supply and 56% a disconnection plan of certain services (see also Table 9-2). However, as explained in section 9.2.7, crisis management should be able to deal with potentially more prolonged and more severe events. In this respect the current HEP is inadequate.

Several stakeholders point out that the positioning of these emergency generators in the building is often suboptimal. In new buildings, these generators are installed on higher levels of the building, while older structures have these on lower floors, making them sensitive to issues such as flooding (Anonymous, 2021a).

8.1.4.2 Risk management

In section 9.2.4 we discuss risk assessment by carrying out stress testing to assess the resilience of healthcare infrastructure. Within the stress test one starts with the evaluation of systems within the physical boundaries of the healthcare facility. But as many of these systems are dependent on external services that fall outside of the property or authority of the facility, it is of importance to identify how external services are critical to healthcare operations. This is especially the case for the energy sector, also because of its high interdependencies with other sectors increasing the risk for cascade effects.

8.2 IT-INFRASTRUCTURE

8.2.1 Current situation

Data networks and IT infrastructure are crucial for the functioning of modern healthcare facilities. Digital medical records must be available for consultation, appointments are recorded electronically, medical devices, digital imaging and archiving, digital pharmacy etc. are coupled to data networks. The integrity of servers, IT networks, communications, call & control centres and data centres used to facilitate these medical services is also essential. Data centres can be divided into a tiered classification system, based on several tiered benchmarks relating to uptime, fault tolerance and availability in general. More information on the Tier 1-5 criteria can be found online[1]. With this classification system companies can get an independent insight into how it fits in with their needs and what a company can expect from the facility. There is a huge variety in the tier level of the data centres in existing hospitals and healthcare facilities. Some health care facilities have little room on-site to accommodate the needs of a new modern data centre, which can lead to a move off-site.

8.2.2 Expected changes

Overheating of electronic equipment is rare these days since all IT-infrastructure is air conditioned. There is however the tendency that new computing equipment is usually more compact, which allows more technology to be stored in the same space. This might create power and cooling issues that can

[1] https://www.digitalrealty.nl/data-centre-tiers

affect the reliability of the entire data infrastructure.

8.2.3 Current and planned measures

Stakeholders point out that risks for overheating of technological devices are sufficiently managed in hospitals (where this issue is most pressing) (Anonymous, 2021a).

8.2.4 Gaps between risks and current/planned measures - Adaptation actions and recommendations

Several stakeholders in the interviews mention the need for knowledge sharing on IT infrastructure. For example, several automatic protocols may exist which shut down cooling or heating in one area of the hospital, because of overactive cooling elements in another area of the hospital. In other words, certain protocols may have adverse effects which may only be noticed through experience. It is then important for IT teams in hospitals to share these experiences, for example through the means of a checklist, to point other teams to a potential adverse effect. Due to the technical and sensitive nature of this information, sharing this information in an anonymous way, by giving input for an IT protocol checklist for example, is preferred by these stakeholders (Anonymous, 2021a).

9. CRISIS AND RISK MANAGEMENT IN HEALTHCARE SECTOR

Crisis and risk management need to take into account the changing climate as climate effects affect all steps of the risk cycle shown in Figure 9-1.

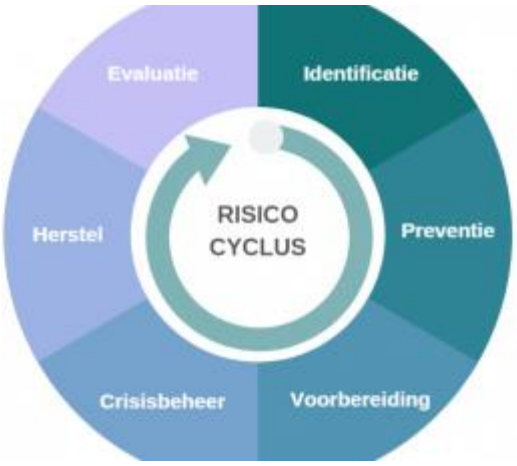

Figure 9-1 Representation of the risk cycle. Source: https://crisiscentrum.be/nl/inhoud/risicocyclus.

Crisis- and emergency management plans are important, but they are not the first steps in the risk cycle. The first step consists of the identification of the main risks to which society may be exposed, followed by the identification and implementation of measures to prevent these risks or limit their impact. A clear picture of the risks can expand or refine existing emergency planning and help to manage emergencies.

9.1 CRISIS AND EMERGENCY MANAGEMENT

9.1.1 Current situation

Crisis management and emergency planning is organized at different levels in Belgium. At the federal level the NCCN ('Nationaal Crisiscentrum' in Dutch, 'Centre de crise nationale' in French) is responsible for public safety, emergency planning, crisis management, risk management, and civil protection. In the event of a crisis the NCCN coordinates the interdepartmental and interdisciplinary action of the government with all the services and sectoral authorities concerned. It provides logistic support and crisis communication. The civil protection can reinforce local services. Belgian Defense intervenes in the national crisis management in case of natural disasters to reinforce the civil capacities (fire brigade, civil protection, police, etc.). When civilian capacities are insufficient in the event of a crisis or disaster on national territory, defense can be called in via the provincial and/or federal government in charge of crisis management.

In case of a threat to public health, the Risk Assessment Group (RAG) analyzes the risk to the population on the basis of epidemiological and scientific data. Based on the advice of the Risk Assessment Group, the Risk Management Group (RMG) decides which measures are needed to protect public health. The RMG and RAG are under the supervision of the IMC public health.

At the national, provincial and local level multidisciplinary and monodisciplinary intervention and emergency plans exist. Within the monodisciplinary plan of discipline 2 (the medical, sanitary and psychosocial assistance) the Medical Intervention Plan (MIP) gives guidance to prepare municipal, provincial and federal general emergency and intervention plans.

9.2 RISK MANAGEMENT

9.2.1 Current situation

The National Crisis Centre is developing additional expertise in the field of risk analysis. This in the field of both security and safety. Moreover, both physical (e.g. sabotage, terrorist attack) and logical (e.g. cyber-attack, hostile takeover) risks are analyzed.

Critical infrastructure sectors have been defined whose assets, systems, networks are considered vital or essential for the functioning of a society and economy. Amongst the critical infrastructure are the sectors energy, transport, finance, healthcare (care infrastructures, hospitals, private hospitals, drinking water, digital infrastructures)[1].

9.2.2 Expected changes

See section 9.2

9.2.3 Current and planned measures

9.2.3.1 General

A large-scale risk assessment for Belgium for the period 2018-2023 was carried out, resulting in the report "Belgian National Risk Assessment 2018-2023'[2]. For this risk assessment, experts analyzed the probability and impact of various risk scenarios, climate change impacts were considered for different themes: natural risks, techno-economic risks, health risks and man-made risks. The resulting climate-related scenarios were implemented in the risk management and emergency management structures of the NCCN. This action suits within the objectives of the NAP2017-2020 as well as in the federal contribution to the NAP.

Defense intervenes in the national crisis management in case of disasters to reinforce the civil capacities (fire brigade, civil protection, police, etc.). With the expected increase in climate-related disasters they expanded their contribution to manage the consequences in the event of a disaster.

The Flemish Adaptation Plan 2021-2030 aims to increase the coherence between climate adaptation and disaster risk reduction. One of the planned measures is the successful coherence in knowledge databases, policies and measures. This would reduce the risk of duplication of effort and lack of coordination at different policy levels and contribute to better preparedness for and response to climate-related disasters. One needs to be able to understand and manage multiple risks, sequencing of risks and cascading risks. This can be achieved by developing support tools, using nature solutions for promotion and design of integrated measures. After approval of the Flemish adaptation plan, the different strategies will be materialized in a multi-annual action plan. The strategy coordinator of this transversal objective is the Flemish Department Environment.

9.2.3.2 International collaboration

Following the adoption of the Sendai Framework for Disaster Risk Reduction, Belgium appointed a national focal point, located in the Ministry for Foreign Affairs. A National Sendai Platform brings together experts from different disciplines. Experts on adaptation to climate change are also present to make the link with the impacts of climate change.

Cross-border cooperation is also ensured, particularly within the Benelux and Pentalateral Energy frameworks, for details see section 8.1.3.2. Specific workshops on the impacts of climate change on health, transport and energy have provided an opportunity to exchange information and learn from each other. It is planned that this collaboration will continue in the coming years(Benelux, 2019).

[1] http://www.ejustice.just.fgov.be/cgi_loi/change_lg.pl?language=nl&la=N&table_name=wet&cn=2019040715

[2] https://www.risico-info.be/nl/informeer-je/wat-zijn-de-risicos-belgi

The Belgian First Aid & Support Team (B-FAST) intervenes in the event of rapid emergency assistance in the event of a disaster abroad. Belgium also has experts trained in European coordination that it can make available to the EU or use in Belgium. In the context of European capacity for urgent intervention, Belgium's pumping capacity (in case of flooding) was significantly increased.

The aforementioned international collaboration actions in the field of risk and crisis management, are realized in the context of the federal contribution to the NAP.

9.2.3.3 Hospitals

The HEP foresees a tool[1] for hospitals in order to carry out a risk and vulnerability analysis for different types of risks:

- Natural risks: including heat, storms, drought, rain, flooding, wind, forest fire, food intoxication etc.;
- Technological risks;
- Human risks;
- Incidents involving hazardous substances;
- Fire.

The impact was considered on humans (death or injury), material (loss and damage), business (disruption in services), preparation (pre-planning), internal response (time, effectiveness, resources) and external response (government, emergency services and resources)

For the different type of events, and for the 6 impact categories, two scores were given:

- a score for the probability of occurrence of the hazard;
- a score for the impact (or severity) created should the hazard occur.

These two aspects, probability of occurrence and impact should the hazard occur, are independent and determine together the risk. A risk score can be calculated by multiplying the probability and impact scores. In the PIEVC protocol the 0-5 probability and 0-5 impact scores, give risk scores from 0 to 25. This risk score was transformed to a percentage scale as shown in Figure 9-2.

RISICO & KWETSBAARHEIDSRISICO BEOORDELINGSTOOL
NATUURLIJKE RISICO'S

GEBEURTENIS	KANS	ERNST							RISICO	RISICO
		MENS	MATERIEEL	BEDRIJF	VOOR BEREIDING	INTERNE RESPONS	EXTERNE RESPONS			
	Voorkomen	*Overlijden of verwonding*	*Verlies en schade*	*Verstoring in dienstverlening*	*Preplanning*	*Tijd, effectiviteit, bronnen*	*Overheid Hulpdiensten en middelen*		*Relatieve bedreiging**	*Score*
SCORE	*0 = ondenkbaar 1 = Zeer laag 2= Laag 3 = Matig 4 = Hoog 5 = Zeer hoog*	*1 = Zeer laag 2= Laag 3 = Matig 4 = Hoog 5 = Zeer hoog*	*1 = Zeer laag 2= Laag 3 = Matig 4 = Hoog 5 = Zeer hoog*	*1 = Zeer laag 2= Laag 3 = Matig 4 = Hoog 5 = Zeer hoog*	*1 = Zeer hoog 2 = Hoog 3 = Matig 4 = Laag 5 = Zeer laag*	*1 = Zeer hoog 2 = Hoog 3 = Matig 4 = Laag 5 = Zeer laag*	*1 = Zeer hoog 2 = Hoog 3 = Matig 4 = Laag 5 = Zeer laag*		*0 - 100%*	*0 - 100%*
Epidemie	2	4	1	3	4	2	3	3	23%	2
Hitte	3	2	2	1	2	2	5	3	28%	3
Plagen/voedselvergiftiging	2	1	1	1	2	2	5	2	16%	1
Aardbeving, aardverschuiving, ...	1	1	1	1	5	5	5	3	12%	1
Koude, ijzel, sneeuw	3	1	1	1	3	3	5	3	28%	3
Storm	3	1	1	1	3	3	5	3	28%	3
Droogte	2	1	1	1	5	5	5	3	24%	2
Regen	3	1	2	1	4	4	2	3	28%	3
Overstroming	2	1	2	1	4	4	2	3	19%	2
Windhoos, tornado, orkaan	1	1	1	1	5	5	5	3	12%	1
Springvloed	1	1	1	1	5	5	5	3	12%	1

Figure 9-2 Screenshot from HEP tool for risk and vulnerability assessment.

[1] https://www.health.belgium.be/nl/tool-om-de-risico-analyze-van-uw-ziekenhuis-uit-te-voeren#anchor-32643

9.2.3.4 Medical equipment

The Belgian health system has set up a strategic inventory reserve for certain essential pharmaceuticals and medical devices. This creates buffers along the supply chain to ensure their availability in the face of a shock (HSPA, 2020).

For hospitals there is a risk associated with the storage of medical gases and medical waste in case of e.g. flooding. Environmental legislation provides general conditions necessary for safe storage of medical gases and waste. During an interview with stakeholders it was made clear that the current regional legislations provide sufficient protection for medical gases as well as medical waste against flooding (Anonymous, 2021a).

9.2.4 Gaps between risks and current/planned measures - Adaptation actions and recommendations

9.2.4.1 Climate risk assessment for healthcare facilities

Step 1 of the risk cycle, namely the identification of health-related risks, needs to be elaborated for climate-related threats. This corresponds to the 2nd step in the adaptation support tool: "assessing risks and vulnerability to climate change" (Figure 4-2). Risk assessment is the process of identifying hazards, their probability of occurrence and the impact created by those hazards should they occur.

A stress test is designed to assess to what extent the current system can cope with the expected climate effects and to identify conditions under which it would be difficult for the health system to maintain its essential function (Ebi et al., 2018). A climate stress test focuses on acute and chronic climate-related events and conditions, that could directly impact health systems and/or climate-related events and conditions in non-health sectors that can indirectly impact health or health system function. The process of a stress test requires the involvement of the healthcare team and multi-sectoral stakeholders. The stress test can focus on one or more of the building blocks of health systems, with the aim of improving system resilience, robustness, redundancy, and coordination. Ebi et al. (2018) provide detailed methods and guidance for conducting climate and health stress tests. They focus on three primary activities: (1) preparing and scoping the stress test, (2) successfully conducting the stress test and (3) communicating the results to key stakeholders to facilitate policy and programmatic reforms. The results of stress tests can provide information to protect population health and manage climate-sensitive health outcomes, and to identify interventions that could maintain essential system functions despite these shocks and stresses.

Climate risk assessment of hospital infrastructure in Canada

In Canada the Public Infrastructure Engineering Vulnerability Committee (PIEVC) protocol[1] has been used to assess climate change vulnerability of various types and scales of infrastructure, amongst which a hospital. Within the protocol, the hospital infrastructure was divided in different categories according to engineering disciplines (e.g. mechanical, electrical, structural, enclosure, water, civil …). These categories were then further subdivided into different components. As the systems within the physical boundaries of the hospital facility often are dependent upon external services, these are also critical to hospital operations. Off-site critical services were identified such as energy delivery, telecommunications, water, etc.

For different climate-related hazards, every infrastructure component or system, both on- and offsite, got two scores:

- a score for the probability of occurrence of the hazard;
- a score for the impact (or severity) created by the hazard on the functioning of the hospital infrastructure and operations should the hazard occur. There exist different methods of impact

[1] https://pievc.ca/

(or severity) scoring.

These two aspects, probability of occurrence and impact should the hazard occur, are independent and determine together the risk. A risk score can be calculated by multiplying the probability and impact scores. In the PIEVC protocol the 0-7 probability and 0-7 impact scores, give risk scores from 0 to 49 as shown in the risk matrix of Figure 9-3.

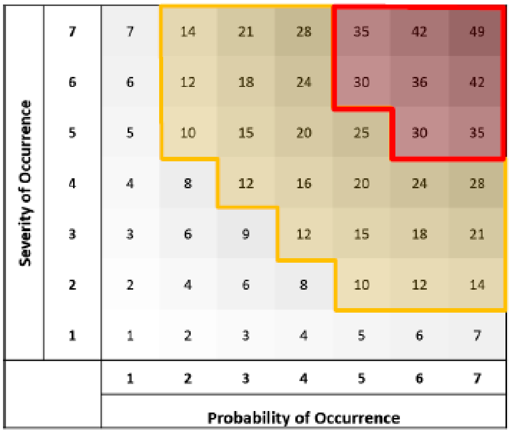

Figure 9-3 Risk matrix, figure taken from[1].

For every climate hazard and infrastructure component, a risk score was calculated. This permitted a refined evaluation of possible climate interactions with respective infrastructure components sub-system. The development of the scoring framework/risk rating for each possible interaction, results in an evaluation of the hospital campus-wide risk.

In the assessment, the focus was on new vulnerabilities caused by future climate change effects. As the systems within the physical boundaries of the hospital facility often are dependent upon external services, these are also critical to hospital operations. A relationship chart can help to illustrate the interconnections between climate parameters, external services and internal services.

Following the risk assessment, the PIEVC protocol uses an engineering analysis to further refine the vulnerabilities of the infrastructure components and systems with a high-risk score. For every infrastructure component an assessment is made of the current loads, the projected change in loads, and the projected change of the infrastructure component. It then assesses the existing capacity and how that capacity will change in time. This information can be further used to define the required level and extent of adaptation of these vulnerable systems.

The PIEVC protocol is a participatory tool that requires a project team consisting of clinical and technical staff of the facility under investigation, local stakeholders, engineers experienced in hospital design, climate scientists, etc.

Climate risk assessment of vulnerable functions in Netherlands

In the Netherlands a framework has been set up to protect vulnerable and vital functions (from sectors energy, IT, water, health, transport, industry) against climate-related risks (de Klerk et al., 2021). These risks include flooding, drought and heat. The framework consists of 6 steps as illustrated in Figure 9-4. While Ebi et al. (2018) uses the concept stress test both to identify vulnerabilities but also interventions to maintain essential system functions, the Dutch framework uses the term stress test to identify the vulnerable functions.

[1] https://klimaatadaptatienederland.nl/overheden/vitale-kwetsbare/bescherming/risicos/methodes-risico-afwegen-beslissingen-nemen/risicomatrix/

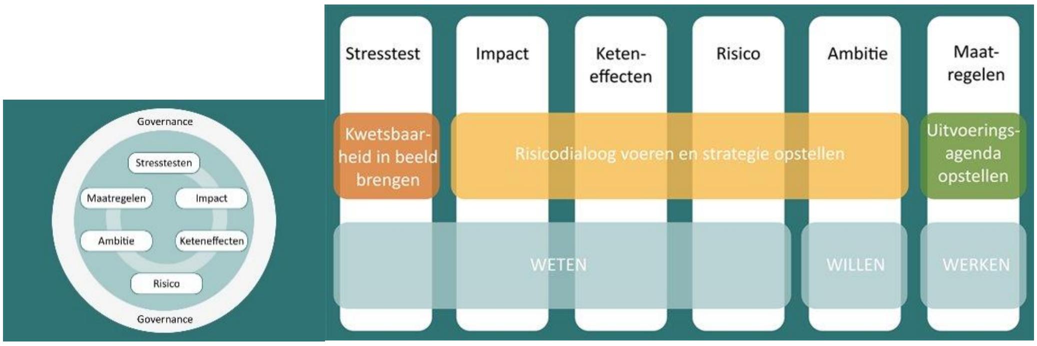

Figure 9-4 Schematic overview of the Dutch framework to protect vulnerable and vital functions, figure taken from [1]

A guidance on a standardized stress-test to identify the vulnerable functions has been developed within the Deltaprogramma Ruimtelijke Adaptatie in cooperation with many stakeholders, and is online available[2]. The guidance is a collection of instructions for carrying out the test (background information on climate and vulnerabilities, input data, calculations, uncertainties, etc.) and it gives advice on the use of the outcome with various stakeholders: transferring and interpreting results in risk dialogue. In addition, for each climate theme, specific instructions, information availability, standards to be applied, … are given.

Climate stress-tests must be carried out in the Netherlands at the level of province, water authority, municipality. An overview is available online[3].

Pilot projects show that the step towards local and regional practice is difficult. One of the reasons mentioned is that (network) managers are not willing or allowed to provide confidential information about the locations and vulnerabilities of their infrastructure available. Nevertheless, it is important that local and regional authorities are aware of the vital infrastructure located in their territory. For example, it is important to know whether in case of flooding or extreme rainfall there are risks to the supply of electricity, gas and drinking water. Even if areas are not flooded, such utilities may fail because production sites, infrastructure or other objects elsewhere are flooded (so-called cascade effects). Vulnerability to loss of vital functions must therefore be considered on a regional basis. There is no compulsory stress-testing of individual healthcare infrastructure in the Netherlands. For the impact assessment, the Dutch framework has special attention for cascade effects. The following steps are the risk assessment, by combining data on the probability of occurrence and impact. The Dutch framework puts a participatory approach at all steps forward.

Climate risk assessment of healthcare infrastructure in Belgium

In Belgium, no climate stress-testing for healthcare facilities has been carried out on a large scale. Only for flood hazards, vulnerable parts in Antwerp hospital infrastructure have been identified in the framework of the Climate-fit.city project, details in section 7.2.4.1. The likelihood of occurrence of pluvial flooding has been determined, but the impact of the flooding on the functioning of the hospital infrastructure has not been assessed.

The HEP tool for risk- and vulnerability assessment (see section 9.2.3.3) can serve as a basis for a risk and vulnerability assessment. However a more detailed interaction with services outside the hospital should be considered, including cascade effects.

[1] https://klimaatadaptatienederland.nl/overheden/vitale-kwetsbare/bescherming/
[2] https://klimaatadaptatienederland.nl/stresstest/bijsluiter/vitaal-kwetsbaar/
[3] https://klimaatadaptatienederland.nl/stresstest/monitor/kaart/

9.2.4.2 Cascade effects

The hypothetical scenarios used in climate-stress tests can range from relatively simple (e.g., heatwave outside historic experience during which the power grid fails) to more complex scenarios, including, for example, interacting and cascading events (e.g., heatwave coupled with wildfires that significantly affect air quality and also affect agricultural productivity) and/or events that affect supply chains (e.g., flooding that limits the ability to bring in needed supplies of medicines, food, and water, or the ability of affected individuals to reach healthcare). The latter are important in order to raise awareness of cascade effects in other sectors or other areas that indirectly have impact on healthcare infrastructures.

Cascade effects can be visualized in various ways:

- One can visualize the impact of external factors on the functioning of one's own function;
- One can map out the impact on other functions if one’s own function fails;
- One can map out all cascade effects for an entire system or entire region and determine the impact on various systems/functions.

By analyzing the successive events when a function fails, one gets a better understanding of where and how cascade effects occur. There exist different tools to map out dependencies in a network and to determine the effects, e.g. CIrcle tool[1].

9.2.4.3 Awareness for new risks

Ebi et al. (2018) state that vulnerability and adaptation assessments often do not explore potential health risks of climate change far outside the range of recent experience with extreme weather events and other climate-related hazards. Scenarios should be tailored to the region of interest, accounting for local factors that could affect the magnitude and pattern of the hazard or response. However, they should also describe threats that are beyond historic experience to account for possible future climate change impacts. The scenarios should test the capacity of health systems to manage shocks and stresses projected with climate change in the coming decades, with lower probabilities but more severe consequences. Real-world events experienced in similar geographic settings and plausible, yet currently infrequent, events, may be used in cases where high-quality data and modelling capacity are low.

This awareness of and accounting for new risks follows also from the analysis of the 2009 heatwave in southern Australia (NCCARF, 2010). They concluded that scenario testing should be undertaken for potentially hotter and more prolonged events on service continuity by infrastructure and essential service providers. Such analysis needs to be system wide to explicitly account for cascading effects.

As mentioned, the notion exists among healthcare professionals that the next pandemic or health crisis may be something entirely different and require new types of actions from the sector. In order to be better prepared, several elements are raised. Stakeholders mention a type of **scenario-based exercises** which could result in a type of script which can then be adapted to the needs of each institution.

Going through several scenarios and identifying points of improvement or good case practices can help health care institutions in preparing for emergencies or extreme conditions. Here, it has been pointed out that preparing personnel for very specific crises, may be inefficient due to the uncertainty of specific vector-borne disease or extreme weather conditions. Rather, the idea would be to have a better grasp of general important communication channels and crucial activities to perform when such a risk occurs (Anonymous, 2021a).

[1] https://circle.deltares.org/index.php

9.2.5 Expected changes

Climate change will most likely increase the occurrence, intensity and duration of extreme weather events, with increasing risks of cascading effects.

Heat waves can affect the entire Belgian territory, however there are geographical differences with larger exposure and vulnerability expected in cities (see also section 5.1.3.1.1). An extra risk is associated with the increased risk of fire during hot and dry periods.

The effects of storms and flooding are more geographically located and require emergency management at the local to provincial level.

9.2.6 Current and planned measures

For measures related to general crisis and emergency management, we refer to the measures related to risk management as described in section 9.2.3.1.

The online survey among stakeholders in the health care sector asked for which types of alerts related to extreme weather events they received some type of alert or message from the government level (local, regional, federal), excluding from the general news and weather-related news sources. Additionally, they were asked which alerts or messaging they would prefer to get in the future, in addition to what they receive currently, in order to prepare better (Anonymous, 2021b). Table 9-1 indicates their answers.

Table 9-1. Current or preferred alerts regarding extreme weather conditions in healthcare facilities (1).

Extreme weather condition	Share of respondents currently receiving alerts (2)	Share of respondents preferring additional alerts (3)
Heatwave	58,30%	54,80%
Heavy wind or storm	11,30%	46,10%
Heavy rainfall or risk of flooding	10,40%	47,00%
Other (4)	6,10%	7,00%
I don't know	19,10%	7,00%
None of the above	18,30%	14,80%

Note: (1) Multiple responses were possible; (2) Answer to the question "Does your health care facility receive an alert or message from the government (local, regional, federal) when one of these extreme weather conditions occur, aside from general weather-related or general news in the media)?; (3) Answer to the question "For which extreme weather condition(s) would you prefer to receive an alert or message to be able to prepare better (in addition to alerts that you potentially already receive)?" (4) 'Other' allowed respondents to fill other responses than those provided.

Other types of alerts that were received were the BE-Alert and signalling about snow and frost; other types of alerts that were preferred also almost exclusively noted signalling about extreme cold, snowfall and frost (Anonymous, 2021b).

Table 9-1 indicates that aside from alerts for heat waves, many alerts are not signalled towards healthcare facilities specifically. However, about half of the institutions believes this would be useful for better preparation. As a result, opinions seem to be rather divided on this point. This could reflect the risk perception of respondents as well: if flooding is not viewed as an important risk at this point, additional alerts may not be of much benefit.

9.2.6.1 Hospitals

In a hospital system there should be intrinsic redundancy to overcome limited shortages and potential concurrent lapses in services. As mentioned in section 3.4 every hospital (network) has a Hospital Emergency Plan (HEP), this is designed to support the monodisciplinary plan of Discipline 2, without being part of it. The federal government provides a template and guidance to set up a Hospital

Emergency Plan, the concrete elaboration for a hospital (network) is done in consultation with the local emergency and intervention plans. The recent Health Systems Performance Assessment (HSPA) assessing the resilience of health systems in Europe mentions that the Belgian HEP is foreseen to deal with e.g. mass casualties from terrorist attacks (HSPA, 2020). Table 9-2 gives an overview of the aspects included in the HEP of general and academic hospitals (Anonymous, 2021b).

Table 9-2. Aspects included in internal HEP of general and academic hospitals.

Elements in HEP	Share of respondents
Emergency power: capacity, location of emergency generators	94,40%
Water: back-up supply of drinking/table water	83,30%
Medical gases: reserve capacity	83,30%
Location of essential installations and ICT	77,80%
Emergency power: fuel supply for emergency generators	72,20%
Emergency power: disconnection plan of certain services	55,60%
Waste water disposal: non-return valves in sewers	33,30%
Storage tanks: anchor and protect	27,80%
Water: disconnection plan of certain services within the facility	22,20%
None of the above	5,60%

Table 9-2 indicates that nearly all hospitals dispose of emergency power, but not all aspects are covered in the HEP e.g. fuel supply as well as a disconnection plan. Reserve supply of water and medical gases is in 83% of the plans in place, but protective measures in case of flooding (e.g. non-return valves in sewers, anchoring of storage tanks, disconnection plan) are not implemented generally. The location of ICT-equipment is also covered by most HEPs.

As mentioned in section 3.4 a Hospital & Transport Surge Capacity Committee (HTSC) was established early March 2020. This committee develops measures and guidelines on the surge capacity of hospitals and the transport of patients.

Critical infrastructure sectors have been defined whose assets, systems and networks are considered vital or essential for the functioning of a society and economy. Amongst the critical infrastructure are the sectors energy, transport, finance, healthcare (care infrastructures, hospitals, private hospitals, drinking water, digital infrastructures)[1]. Hospitals are considered as critical infrastructure and hence are secured from supply logistics.

9.2.6.2 Residential care

In residential care for elderly or disabled people, revalidation centres, etc. internal emergency plans exist like required in all public services. The internal plan has five functions: alarm, combat, evacuation, communication, after care. The plan is activated in case of an accident inside or outside the centre.

[1] http://www.ejustice.just.fgov.be/cgi_loi/change_lg.pl?language=nl&la=N&table_name=wet&cn=2019040715

9.2.7 Gaps between risks and current/planned measures - Adaptation actions and recommendations

9.2.7.1 Data availability for emergency services

For adequate emergency response it is important to have timely data available in order to optimally deploy the emergency services.

Flood hazard mapping

The flood hazard mapping tool detailed in section 7.2.4.1 can be applied to determine the impact of pluvial floods on vulnerable healthcare infrastructure but it can also be combined with data on vulnerable groups as detailed in section 4.4.2 to estimate their impact. The hazard maps can also be coupled to traffic models.

This type of impact maps can be used in emergency planning; it provides an estimate of the size and location of the impact. In this way, resources can be better deployed to protect vulnerable areas or, for example, to provide alternative access routes for hospitals. The coupling to traffic models allows to assess the impacts on crisis and emergency planning needs (interventions by the fire brigade, police, ambulances, evacuations), and to compute alternative emergency traffic routes.

High-resolution (extreme) weather forecasting

For emergency services real-time forecasting of storms including the locations and type of storm can give important information beforehand. For fire brigades it is of importance to accurately predict whether a storm will generate extreme wind speeds and/or heavy rainfall. This allows to decide on the type of intervention to be prepared for and hence to set priorities regarding equipment.

Current meteorological forecasting makes use of C-band radars of the Royal Meteorological Institute of Belgium (RMI). Although these radars provide weather information of an outstanding quality, the data are too coarse to be used in detailed predictions on the scale of a city or agglomeration. A compact X-band radar with a shorter range but higher resolution could provide emergency services with more detailed radar images and predictions on the scale of a city or agglomeration.

It would be of interest to investigate whether the precipitation data derived from X-band radar data can be coupled to the hydrological models mentioned in section 7.2.4.1 and generate real-time forecasting on the exact location and extent of (flash) floods. This would allow to increase the self-coping capacity of affected households as they can be informed in real time and be given advice tailored to the type of event forecasted. The flooding forecast can be coupled with traffic models in order to forecast which hospitals and/or traffic roads will be flooded, such that alternative roads can be searched for.

Wild fires

As already mentioned in section 7.2.4.3 no data on the present situation nor forecasts are available for wild fires.

9.2.7.2 Awareness for more severe and more prolonged crises

Crisis and emergency plans should be able to deal with potentially more severe and more prolonged events. This was one of the conclusions of the analysis of the 2009 heatwave in southern Australia, this heatwave produced very severe, extensive and long heat exposure and led to a bushfire disaster. The impact of it on the emergency management response was investigated (NCCARF, 2010).

As can be seen from Table 9-2 in the current HEP the assessment of the availability of back-up energy is often limited to the inventarisation of the capacity of diesel generators. Most of the HEPs taken up in the survey do not prepare hospitals for more severe and more prolonged climate-related hazard crises. Elements that could contribute to this are e.g. availability and supply of diesel (for emergency generators) (only 72%), availability of fresh water (83%), medical gases (83%). Also aspects related to supply of medication and food, communication, cooperation with first line, etc. should be covered. This point was also made in a recent KCE-report, namely that the HEP includes disaster-specific components for chemical, biological, radiological, nuclear and explosives, but extreme weather related aspects are less covered (KCE, 2020). The KCE-report also mentions that it would be best to strengthen the function of the emergency plan coordinators and to pay more attention to training on the HEP in the context of disaster exercises (KCE, 2020).

In several countries which experience more severe climate risks than Belgium, toolkits have been designed to increase the sustainability and resilience of healthcare facilities in case of extreme weather conditions, e.g. U.S. Climate-Resilient Health Care Facilities Toolkit[1], Public Health Emergency (PHE) of the U.S. Department of Health and Human Services[2], US Federal Emergency Management Agency of U.S. Department of Homeland Security[3]. These tools and checklists can be inspiring, but they are specifically aimed at the U.S. situation and regulations, which might differ from those in Belgium.

9.2.7.3 Critical infrastructure

Not all healthcare infrastructures are classified as critical infrastructure: residential care homes for elderly people, revalidation centre, centres for disabled people do not fall within this category.

[1] https://toolkit.climate.gov/tool/sustainable-and-climate-resilient-health-care-facilities-toolkit

[2] http://www.phe.gov/Preparedness/planning/mscc/handbook/chapter2/Pages/default.aspx

[3] https://www.fema.gov/sites/default/files/2020-08/fema577_design_guide_improving_hospital_safety_2007.pdf

10. RECOMMENDATIONS FOR CLIMATE-HEALTH ADAPTATION

Mitigation measures are essential to limit global warming and climate change. Despite mitigation efforts, the effects of climate change are imminent today and will increase in the future. Hence adaptation measures are at the same time essential to reduce the impact in different sectors and to increase their resilience. Adaptation measures should be taken at the earliest possible stage in order to be as efficient as possible and to limit costs / maximise economic benefits.

10.1 TRANSVERSAL ACTIONS – ONE WORLD, ONE HEALTH – HEALTH IN ALL POLICIES

Consequences of climate change manifest themselves in many areas: agriculture, biodiversity, crisis management, energy, fisheries, forests, health, industry & services, research, tourism, transport, water, etc. It is therefore important to mainstream climate change adaptation by integrating climate adaptation measures into existing policies and programs of multiple policy domains in a joint approach (Wellstead and Stedman, 2015). Human health is not only determined by climate and other environmental factors, but also by our lifestyle, genetic factors and access to healthcare. **Health in All Policies** (HiAP) is an approach to public policies across sectors that systematically considers the health implications of decisions, it seeks synergies and avoids harmful health impacts to improve populations health and health equity. Another concept, **One World, One Health**, recognises that human health is closely connected to the health of animals and our shared environment as well as ecosystems (CDC, n.d.). This has been made clear with multiple examples throughout this report. A One World, One Health approach to climate change adaptation, aiming at the simultaneous protection of humans, animals, ecosystems and the environment from climate change impacts, may significantly contribute to the reduction of health effects of climate change (Zinsstag et al., 2018). In both HiAP and One World, One Health approaches to designing and implementing programmes, policies, legislation and research, multiple sectors at multiple levels need to communicate and work together to achieve better public health outcomes.

Within the NAP 2017-2020 measure 4 aims to set up an integrated vertical and horizontal coordination structure in order to strengthen sectoral coordination at national level (NAP, 2017). It is mentioned that sectoral coordination in terms of climate change adaptation should be strengthened particularly for the themes transport, disaster management, health, energy and agriculture. Round tables have been organized in 2017 (for general public) and 2018 (theme forest fires and climate change). In Belgium, due to the division of competences between the federal and regional governments, the sectoral distribution of competences and the (sometimes partial) privatization of certain sectors, multiply the authorities and services concerned. This makes the coordination and coherence between actions at national, federal and regional levels difficult. In order to make the healthcare sector more resilient against the impacts of climate change, it is of importance to create a horizontal and vertical coordination structure between all sectors involved. ***We recommend the development of a Belgian Centre of Excellence on Climate. This could provide a forum for collecting scientific expertise and knowledge both at national and international level, facilitating the dialogue with stakeholders of various regions and sectors such as healthcare, energy, environment, etc.***

Currently in Belgium, within the multi-institutional structures working on climate change, mitigation & adaptation, at national, federal and regional levels (see section 4.2.3), the health sector is not represented. No ministry is responsible for health and climate change in Belgium, however the NEHAP framework and the Cell Environment-Health (see section 3.2.1) deal with environmental health issues.

We recommend the development of a national health and climate change plan, which considers health risks of climate change as well as of adaptation and mitigation measures, and which assesses health resilience to climate change.

10.2 DATA AVAILABILITY

10.2.1 Climate hazard data

High-resolution climate information is available for Belgium, Flanders and Wallonia (Brouwers et al., 2015; SPW-AwAC, 2011; Termonia et al., 2018). The Belgian projections, carried out within the Cordex.be project, are based on RCP scenarios underlying the CMIP5 climate data of IPCC, the 6th IPCC Assessment Report will be released later this year, the underlying climate data (CMIP6) based on the socio-economic pathway (SSP) scenarios are already (partly) available. ***We therefore recommend creating new high-resolution projections for Belgium based on CMIP6 data, for general climate parameters as well as for health-related indicators.***

Starting from the general climate parameters one can derive health-related indicators such as e.g. for thermal comfort. Because of the high spatial variation (metre scale) of e.g. the WBGT it is important to derive these indicators at high spatial resolution.

Belgian scientific expertise on climate is scattered over different universities and scientific institutions. Within the Cordex.be project expertise of different research centres was combined to develop high-resolution climate scenarios for Belgium. However a structural interaction needs to be created in order to better capitalise on this expertise both at national and international level. The development of a roadmap for a Belgian Centre of Excellence on Climate was foreseen in the national adaptation plan 2017-2020 (measure 2) but this was not implemented (NAP, 2017; NCC, 2021). However, such a structure could provide a forum for collecting scientific expertise and knowledge, facilitating the dialogue with stakeholders of various sectors such as healthcare, energy, environment, etc. A national platform for information concerning climate adaptation is online[1] (measure 3 in NAP, measure 12 in federal contribution to NAP). It contains general information, policy information, a library and dedicated sections for various sectors (e.g. health sector) where the impact and vulnerabilities and adaptation measures are briefly described. It would be of interest if the platform would contain a 'Climate Service for Belgium' including basic climate parameters (such as derived in Cordex.be) as well as sector-specific derived indicators (for examples for the health sector see 10.5). This could be developed in analogy to the Climate Change Service (C3S) of the Copernicus programme that provides datasets and tools for various sectors including a European Health Service[2]. For the Flemish Region the climate platform of VMM will be extended with additional indicators. We note that the maintenance costs of such a service (e.g. updating of information) is high. ***We recommend the set-up of a central website/app 'Climate Service for Belgium' including basic climate parameters as well as sector-specific derived indicators e.g. for drought, flooding, wildfires, health (apparent temperature metric such as WBGT).***

10.2.2 Stressor data: current situation and projections

For the health effects considered in this study, the surveillance and/or monitoring of the stressors fall under the responsibility of different authorities and services. Below we summarize the stressors for which monitoring is suboptimal as well as stressors for which no projections are available:

- For wildfire no detailed risk maps are available for Belgium, except for a wildfire ignition probability map, making use of land use, land cover and soil type data (Depicker et al., 2020). In case of wildfire risk, warning levels are issued at municipality and provincial level. No high-resolution assessment, (short-term) forecast nor projection maps (taking into account fire propagation data including fuel type, fuel moisture, topography and meteorological data such as temperature and wind) are available for the entire Belgian territory. ***We recommend the set-up of an adequate governance structure to establish and regularly update risks maps for***

[1] https://www.adapt2climate.be/ & https://klimaat.be/
[2] https://climate.copernicus.eu/european-health-service

wildfire, as well as for monitoring and forecasting (considering dynamic data on fire ignition as well as on fire propagation).

- The impact of climate change on flooding, drought and wildfire is an important issue, only for Flanders climate projections are available. This remains to be investigated for Belgium based on e.g. the CORDEX.be results (Termonia et al., 2018). ***We recommend to derive flooding, drought- and wildfire-related indicators from the Cordex.be or from future high-resolution climate data for Belgium.***
- Currently there is no permanent monitoring of native and invasive mosquito species, within the MEMO-project the focus was on exotic mosquitoes. ***We recommended the set-up of a long-term monitoring structure for both monitoring and pathogen determination of infected mosquitoes (both native and exotic).***
- Monitoring of a number of vectors and their pathogens in wildlife is in place, this allows to early detect the distribution and prevalence of these vectors. ***We recommend within the One World, One Health concept to extend the existing active and passive monitoring programmes for pathogens in wildlife and to investigate pathways of introduction of exotic species.***
- For bathing water, monitoring of bacterial pathogens, monitoring of dead fish and birds as well as visual inspection for trash/litter is in place. ***To protect bathers against infections with viral and protozoan parasites that persist longer in water, we recommend to perform research to determine the added value of monitoring coliphages.*** Cyanobacteria blooms are monitored in different ways, in Flanders an app will be launched soon to report blooms, while in Wallonia the use of remote sensing data is being explored. Different authorities carry out pilot projects for effective and sustainable control of cyanobacterial blooms. ***We recommend sharing of good practices on cyanobacterial blooms monitoring (including bloom models) between authorities and research centres***. In case of algae blooms, criteria are in place to close water for recreation as well as captation. ***We recommend the revision of the captation and recreation criteria in case of cyanobacterial blooms considering recent guidelines by WHO and US EPA.***
- For ragweed a monitoring program is in place in Wallonia, however in Flanders and Brussels there is no active monitoring. ***We recommend the implementation of ragweed monitoring in Flanders and Brussels, in parallel to the Walloon initiative.*** Regarding the emergence of the allergenic fungus *Cryptostroma corticale*, no monitoring has been structurally set up at national level. So far, only short guidelines have been published by the Public Waste Agency of Flanders (OVAM). ***We recommend the development of a monitoring system for fungus Cryptostroma corticale.***

10.2.3 Vulnerability data

Vulnerability assessment have been carried out at the national level as well as for the three regions. For Flanders and Brussels vulnerability mapping has been performed at the level of the statistical sector. These maps provide valuable information to derive climate impact information. A local vulnerability assessment can provide more detailed information, this is best regularly updated. ***We recommend the assessment of the vulnerability of the Belgian population at the level of a statistical sector, making use of publicly available datasets based on e.g. census data. For local assessment we recommend the development and application of a common methodology as this would result in in homogenous data.*** Vulnerability maps can be crossed with hazard maps (for e.g. heat, flooding) to create impact maps.

10.2.4 Health and epidemiological data

Health data (mortality, hospitalization, emergency department visits, general practitioner visits, medication use, laboratory results, etc.) are being registered but are not available in (near-) real time. Emergency department data are currently being registered but are not further explored. For general practitioners in Wallonia and Brussels no registration is carried out, except for the Network of General

Practitioners. The regional health authorities are responsible for the monitoring of notifiable infectious diseases. Sciensano coordinates the network of sentinel GPs, laboratories and the National Reference Centres for surveillance of epidemiological trends. For self-treated illnesses, data are available from medication use and from the Belgian Health Interview Surveys. However, for some pathologies such as e.g. allergic rhinitis or gastroenteritis symptoms, there is no complete overview available. The Healthdata.be service of Sciensano aims to facilitate the data exchange between healthcare professionals and researchers to increase public health knowledge in Belgium. It offers the following services: making pseudonymised data from the data warehouse available, migrating existing pseudonymised data sets at healthcare actors to the healthdata.be platform, and putting new pseudonymised data sets at healthcare actors into operation.

We recommend the availability of (near-) real-time health data from emergency services, hospitals, general practitioners, laboratories, medication use, etc. both on physiological and mental health. A retrospective analysis of these data can determine the burden of disease for various climate-related stressors such as heat, allergy, ticks, flooding, etc. Sensitivity analyses on parameters such as age, urban population, socio-economic status, etc. can be performed to determine vulnerable groups in the population. A surveillance or monitoring system can be put in place, this can be used as activation criteria of e.g. heat-health plans. For better surveillance of health complaints with respect to water quality for bathing, we recommend the development of a questionnaire system, with a digital questionnaire sent at the end of the bathing season requesting local health departments and provinces to enter the bathing water related health complaints they have received/noted. That information can be compiled into an annual surveillance overview and communicated to stakeholders. Changes in biological hazards due to climate change could increase the share of foodborne outbreaks with unknown causative agents. ***We recommend the set-up of an alert system based on the monitoring of the number of foodborne outbreaks of unknown causative agents. This could identify a possible trend in an early stage and dictate further investigation (retrospective or future oriented monitoring). To facilitate data collection and information gathering, citizens can be encouraged to report their symptoms via an app or social media channels. A similar reporting system could be set up for estimation of the incidence of water-borne diseases (apart from the initiative mentioned above).***

10.2.5 Health impact assessment

In Belgium heat-related mortality data are being monitored. However, no retrospective analysis of heat-related morbidity effects (e.g. hospitalization, emergency department visits, general practitioner visits, medication use) has been carried out so far. ***We recommend an assessment of the climate related burden of disease, possibly time-series of annual data, and to compare the results with other environmental stressors.***

10.2.6 Crisis and risk management data

Concerning the risk of pluvial or fluvial flooding, high-resolution flood hazard maps indicating the location and characteristics (inundation area, maximum inundation depth) of the flooded zones, are not generally available. These flood maps are not available nor for the current situation, nor for future scenarios. ***We recommend the set-up of detailed risk maps for flooding, using hydrological modelling with detailed local data. The required input for hydrological models include precipitation data (intensity, duration and frequency) as well as local data on topography, land cover, buildings, drainage systems, river systems, sewage systems, surface draining systems, infiltration and roughness zones, etc.*** The availability of good-quality hydraulic data is essential for accurate modelling.

Real-time and high-resolution weather forecasting, including the locations and type of storm, can give important information to deploy the capacity of emergency services. ***We recommend the exploration of using X-band radar precipitation data in hydrological models for high-resolution flooding forecast.***

10.3 ADAPTATION MEASURES FOR GENERAL PUBLIC AND VULNERABLE GROUPS

Integrated healthcare services cover health promotion, disease prevention as well as curative care. Adaptation measures should be implemented in the first two aspects of healthcare which are currently underfinanced in Belgium. The current financing system in the health sector is performance-based, this doesn't help to promote preventive care. Hence dedicated financing is needed to implement adaptation measures to improve health of the general population and of vulnerable people. Climate adaptation measures must be implemented at the local level, the involvement of community-based healthcare (e.g. home care, local care, informal caretakers, etc.) is crucial.

Adaptation measures can be taken by an individual or can be organized through an organization or authority. Below we summarize the measures that are currently lacking or the vulnerable groups that are not being addressed sufficiently in the national and regional plans.

- For heat-related effects the urban population is especially vulnerable due to the urban heat island effect. The activation criteria of the ozone- and heat plans do not consider higher night time temperatures in urban areas. ***We recommend investigating other activation criteria such as minimum temperature as well as the use of local forecasts, especially for warning urban dwellers (UHI). The (recommended) retrospective analysis of mortality and morbidity data could be used in the assessment. The results of this analysis could also highlight (health) indicators for which real-time information through surveillance can guide the activation of heath action/alarm plans.*** Elderly people are being addressed in the regional plans, but some general advices are not tailored to them. The heat-related risks of medication are not elaborated in all plans, this is of importance for chronically ill people and mentally ill people. Pregnant women and indoor workers are not addressed in the plans. ***We recommend the inclusion of specific actions for obese people, pregnant women, workers, drug users, homeless people in ozone- and heat plans. More attention should be spent to the effects of medication in the general sections dealing with vulnerable subgroups (currently missing or only in detailed sections for care workers). Inclusion of health effects due to UV radiation as stressor and measures are the same.***
- For health-risks associated with vector-, food- and water-borne diseases as well as for allergic and respiratory diseases, adaptation measures that can be taken by individuals, local and regional authorities are proposed by the relevant authorities and organizations. This information is however scattered by different communication channels used. Concerning vector-borne diseases there is an increased risk for frequent travellers and people spending a lot of time in nature, for e.g. tick-borne encephalitis and West-Nile fever. Further prevention and sensibilization is needed, to avoid spreading of the disease, and inform about symptoms allowing people to contact/inform medical practitioners or prevention workers as soon as they get infected. ***We recommend to expand the target groups of sensibilization campaigns on vector-borne diseases and to address vulnerable groups such as professionals working in nature (ticks) and travelers (mosquitoes) in sensibilization campaigns.***

The majority of Belgian cities and municipalities disposes of a local energy and climate plan, often set up in the context of the Covenant of Mayors. From a consultation of a series of local plans it becomes clear that the actions often remain in the domain of energy efficiency of buildings, spatial planning, urban design or environmental departments. These actions are important to take, but there is a need for further involvement of public health and social care professionals in local adaptation planning and implementation to reduce the human health impacts, including impacts on vulnerable groups. The latter is particularly important as the Belgian healthcare system is further deploying home-based and community-based care to cope with an ageing population as well as with an increasing number of chronically ill people with multimorbidity. In this respect it is important to increase the health literacy of patients. The financing of a local climate-health initiative should provide budget in order to provide appropriate care to elderly, chronically ill and socially isolated people, to prepare for and during extreme weather events (e.g. heatwave, storm, flooding).

Adaptation measures against extreme weather events are included in local energy climate plans. However, in the case of an event, the lack of high-resolution flooding forecast data (see above) not only hampers the adequate deployment of emergency services, but it also inhibits the self-coping capacity of households.

We noticed that often preventive measures against climate stressors are organized by social care organizations (e.g. by community centres and CPAS/OCMW), without noticing them in the municipality's energy and climate plan. However it would be good to include all adaptation measures in the local plan (HiAP and mainstreaming aspect). ***We recommend to further develop community-based care initiatives and to increase the surveillance (e.g. by telephone, visit) of vulnerable people at home during extreme weather events.***

The online survey questioned respondents on which proposals they believe to be useful in increasing the resilience of the general population against climate risks. The results are summarized in Table 10-1. Additional communication about the risks and preventive measures, both towards the general population as well as vulnerable risk groups, is useful according to more than half of the respondents. They also point to the further development of preventive healthcare and community-based care. Other suggestions included sensibilization of certain sectors and settings (e.g. companies, schools, elderly care), dedicated financing for climate-health programs and the use of simple language in communication. (Anonymous, 2021b)

Table 10-1. Online survey results for the question 'Which proposals to increase the resilience of the general population to climate risk are useful according to you?' (1)

Proposal	% of responses	Number of responses
More communication about the risks of climate change towards the general population	68,20%	80
More/better communication and measures for vulnerable groups	59,10%	69
Continuing the development of preventive healthcare and community-based healthcare (e.g. home care, local care, informal caretakers, etc.)	49,10%	57
More attention for tele-monitoring (e.g. the use of wearables) and tele-consults	26,40%	31
Other (2)	7,30%	9
None of the above	2,70%	3
I don't know	6,40%	8

Note: (1) Multiple responses were possible; (2) 'Other' allowed respondents to fill other responses than those provided.

We recommend setting up a governance structure at the (supra-)local level to create a platform with all stakeholders in the domains of social care, health care, wellbeing, spatial planning, environment and health, education, etc. In this way the set-up, implementation and evaluation of local climate-health plans can form a basis for many current and future (urban) development projects, realizing health in all policies. This governance structure can be set up at the level of a community or at supra-local level, like is now the case with the COVID-19 vaccination centres.

This local governance structure could appoint a central contact for the **communication** to the general public and to professionals in local (health) care organizations or initiatives. This information can be further distributed through the local website and social media, billboards, educational initiatives (e.g. in schools & libraries), community centres, waiting rooms with general practitioners and hospitals, pharmacists, recreational rooms in residential healthcare facilities, etc.

To reach **vulnerable groups**, it is important to map their social network and to have an overview of organizations and intermediaries through which one can reach them. ***We recommend identifying at a regular basis vulnerable groups and their social networks to develop communication strategies.***

There are several **citizen science** initiatives dealing with heat, drought, ticks, mosquitoes etc. ***We recommend the further deployment of citizen science initiatives to derive evidence-based local information but also to create awareness amongst the participants and general population.***

10.4 ADAPTATION MEASURES FOR HEALTHCARE FACILITIES

We start with a general remark that was made by many stakeholders, namely there is a general lack of (health)care personnel and appropriate financing throughout the entire (health)care sector. The funding of the Belgian healthcare system is performance-based, leaving little room for prevention and health promotion, preventive care takes only 2.16 % of the total expenditure on health. ***We recommend to increase the financing of the entire (health)care sector, including health promotion and prevention programmes, the roll-out of health management systems and local organization of home- and community-based care. We recommend the establishment and financing of a long-term climate-resilience action plan for healthcare infrastructure.***

Concerning **indoor thermal comfort and air quality** in healthcare infrastructures, there is a great variety in implementation degree. Cooling techniques used in healthcare institutions include the opening of windows (59% of respondents) and standard air-conditioning (40% of respondents). This is complemented with external sunscreens (83% of respondents) or internal sunscreens (58%). The most prevalent ventilation systems used are D (mechanical supply and discharge), A (natural supply and discharge) and C (natural supply, mechanical discharge).

Adaptation measures during **heat episodes** are well in place in almost all healthcare facilities, except for facilities for people with disabilities and rehabilitation hospitals. However the patients or residents in the latter are often particularly vulnerable to the effects of heat. ***We recommend the compulsory set-up of heat-health action plan for all facilities and hospitals, both residential and non-residential (including child care facilities, schools, shelters for the homeless, drug rehabilitation centres, etc.).*** An important challenge for the implementation of heat plans in healthcare facilities lies in the sensibilization of personnel and changes in daily habits. The current practice in residential care of cancelling non-essential activities to compensate for the extra heat-related care is not sustainable. This might work for a limited period, but not throughout an entire summer. ***We recommend the development of sustainable action and personnel management plans during crises, especially heat-related.*** For **vector-, water- and foodborne diseases**, all university hospitals dispose of a protocol, but for other healthcare facilities the availability of a plan or protocol is around or lower than 50%.

The **implementation of adaptation measures** often means provision of extra care as well as the acquirement of new skills, this means extra workload for the healthcare personnel. More healthcare personnel is needed in order to guarantee a high level of care during extreme weather conditions. ***We recommend the establishment of legal framework for implementation of current (COVID-related) measures (and others, e.g. list of reserve doctors) in future health crises, and to increase flexibility between different lines.***

As can be seen in Table 10-2, from both the interviews as well as the online survey, different important aspects stand out to increase the resilience of healthcare personnel and healthcare infrastructure to climate risks. There is the need for support and **technical guidelines** specifically applied to the healthcare sector. This is already covered by the regional health agencies (AVIQ, AZG, COCOM) and by the VIPA and UREBA programs, but so far the focus has been on energy efficiency. Within the VIPA program there is a recent tendency towards investments to create a healthy environment with e.g. ventilation guidance and the possibilities of green & blue infrastructures. ***We recommend the further provision of technical guidelines (not additional legislation) and means of application related to energy efficiency, cooling and ventilation, flooding, etc., for use specifically in the healthcare sector. The elaboration of VIPA- and UREBA-programmes for adaptation measures, including green and blue infrastructures to create healthy environments.***

There is willingness to **share knowledg**e within the different lines of the healthcare sector and between different types of institutions. Within the COVID-context this collaboration was initiated but it should be more than an ad-hoc initiative.

Table 10-2. Online survey results for the question 'Which proposals to increase the resilience of health care personnel and infrastructure to climate risk are useful according to you?' [(1)]

Proposal	% of responses	Number of responses
(Additional) Technical guidelines specifically applied to the healthcare sector	61,50%	72
Working groups which develop example protocols for the healthcare sector	56,90%	67
Partners, architects, … to bring adaptation measures into practice specifically for the healthcare sector	45,00%	53
Measurement of the sensitivity and resilience for climate risks (i.e. climate 'stress test')	34,90%	41
Including indicators of the sensitivity and resilience in the quality system	33,90%	40
Other [(2)]	7,30%	9
None of the above	7,30%	9
I don't know	3,70%	4

Note: [(1)] Multiple responses were possible; [(2)] 'Other' allowed respondents to fill other responses than those provided.

The need for an assessment of the **sensibility and resilience of the healthcare infrastructure** (e.g. by conducting stress tests) was mentioned by 1 out of 3 respondents. A risk assessment for healthcare facility considering the dependency of off-site critical services and the possibility of cascading effects, has not been carried out for Belgian healthcare facilities. 1 out of 3 respondents proposes to include indicators concerning the sensitivity and resilience in the quality system. ***We recommend the set-up of a protocol for stress testing of healthcare infrastructures, in the scenario-based exercises new risks as well as cascade effects need to be included.***

Other elements cited by the respondents exclusively addressed the need for **additional financing** for the adaptation of buildings and healthcare personnel. This was also the top answer for the question on the type of government support that is currently insufficiently provided but which could increase the resilience of the healthcare system, see Table 10-3.

Additionally, both during interviews and as 'other' answers to this survey question, respondents are open to more information and guidelines, but are generally opposed to the idea of more rules and strict requirements in terms of adaptation measures. There is a strong call for the option to differentiate the adaptation measures based on the reality and needs of a specific health care institution (Anonymous, 2021a, 2021b).

Table 10-3. Online survey results for the question 'Which government support is insufficiently provided which could increase the resilience of the health care system?' [(1)]

Proposal	% of responses	Number of responses
Financing to implement adaptation measures	84,00%	98
Information and (technical guidelines) for adoption measures	55,70%	65
A clear vision on the resilience against risk of climate change for the health care sector	50,00%	59

Clear communication (channels) and contact points (e.g. during crisis situations	43,40%	51
I don't know	6,60%	8
Other [(2)]	0,90%	1
None of the above	0,90%	1

Note: [(1)] Multiple responses were possible; [(2)] 'Other' allowed respondents to fill other responses than those provided.

Government support is also needed to establish clear **communication** channels and contact points to the medical sector. Depending on the type of event, different organizations or authorities communicate to the healthcare sector:

- For extreme-weather related events RMI provides warnings at the provincial level, but they do not communicate directly to the healthcare sector.
- During the warning phase of the ozone- and heat plan communication is performed by the regional health authorities, during the alarm phase by the FPS-Health.
- Concerning epidemiological surveillance, communication is performed by the authority or organization that is competent for the surveillance.

Despite the fact that communication channels, although fragmented, are in place, the survey among stakeholders in the healthcare indicates that many healthcare facilities do not receive alerts from a governmental organization, especially in the case of forecasted storms, rainfall, flooding and concerning vector-borne diseases. About half of the respondents indicates they would like to receive additional information. Because of the fragmented information, the healthcare sector is worried that this might result in late identification of new trends. It would be beneficial to streamline the communication channels. Especially in a crisis situation it is crucial for the healthcare sector to have a clear point of contact. ***We recommend streamlining communication channels from surveillance and meteorological organizations to medical practise. The information should be tailored specifically to the needs of the (possibly different types of) receivers, this might involve the set-up of a multisectoral organ. The establishment of clear points of contact is especially important during crises.***

Throughout the interviews, the **sharing of good practices** within the medical sector, came forward as a useful way for healthcare institutions to share knowledge. In the online survey, healthcare institutions were asked within which structure this knowledge sharing should take place. Results are indicated in *Table 10-4*. Regardless of whether this knowledge sharing takes place in an existing or new structure, respondents point out that this implies a time investment. Considering the existing issues with capacity and staffing, the success and willingness to participate of such a structure will depend on financial compensation.

Table 10-4. Online survey results for the question 'Which type of consultation or meeting structure would be most useful to share good practices?' [(1)]

Proposal	% of responses	Number of responses
Within first line zones	27,50%	32
Within hospital networks	30,30%	36
Across levels in the healthcare sector (across 1st, 2nd, 3rd line and policy)	49,50%	54
Within existing meeting structures (e.g. association of environmental coordinators, prevention advisors, engineers, etc.)	66,10%	77
Within a new structure	1,80%	2
Other [(2)]	2,80%	3

None of the above	1,80%	2
I don't know	10,10%	12

Note: (1) Multiple responses were possible; (2) 'Other' allowed respondents to fill other responses than those provided.

We recommend financial compensation to focus more on trainings for health promotion and prevention. This includes initiatives related to good practice sharing of adaptation measures, for example in existing structures of environmental coordinators, prevention advisors, etc.

*In the event of a **crisis**, healthcare facilities are assisted by the local, provincial or national crisis services, depending on the severity of the event. We note that only hospitals are classified as critical infrastructure, they have priority energy supply in case of shortage. This is not the case for psychiatric hospitals, residential elderly care, revalidation centres, centres for persons with disabilities etc. The Belgian health system has set up a strategic inventory reserve for certain essential pharmaceuticals and medical devices. This creates buffers along the supply chain to ensure their availability in the face of a shock. For most hospitals the HEP covers emergency power, backup of water and medical gases, ICT infrastructure. However from the survey it follows that important aspects are not implemented generally by all HEPs e.g. fuel supply, an electricity disconnection plan, non-return valves in sewers, anchoring of storage tanks, etc. This type of measures is however important in the light of more severe and more prolonged climate-related hazard crises. More attention should be paid to training on the HEP in the context of disaster exercises.*

We recommend the extension of the HEP and internal emergency plans to account for longer, more severe hazards, including cascade effects. The function of emergency coordinator should be appointed or strengthened, training of emergency plans should be increased.

10.5 CLIMATE-HEALTH SERVICES

We recommend the set-up of a central website/app 'Climate Service for Belgium' including basic climate parameters as well as sector-specific derived indicators.

At the city- or regional-level several initiatives exist to make climate-adaptation related data available for the general public or for local authorities, emergency services and stakeholders. Below we give some examples of local and regional initiatives that can be upscaled to the area of Belgium:

- Several Belgian cities have on their website a map with the indication of cooling zones (calculated using apparent temperature metrics), cooled public buildings, resting areas in the shade, position of drinking water fountains, etc. This type of information can be further used to indicate cycling- and walking paths in the shade between different green zones. A high-resolution map using e.g. WBGT as temperature metric can be set up for (urban areas in) Belgium (as is currently planned for Flanders).
- In a case-study for Brussels the allergy risk of 18 green spaces has been determined based on tree inventory data (Aerts et al., 2021). At a larger scale airborne LiDAR and hyperspectral imagery can be used to identify individual tree species (Mäyrä et al., 2021). This allows to derive Belgium-wide allergy risk indices e.g. at the level of the statistical sector. A quantification of the allergy risk under different scenarios (e.g. climate changes, removal of certain tree species, etc.) might provide useful information to create new hypoallergenic green spaces.
- For Flanders a tick risk maps with a risk assignment (very high, high or moderate) for every community will be implemented. The methodology used cannot be transferred directly to Wallonia as the data sources used (e.g. presence of deer) differ between Flanders and Wallonia.

We recommend the upscaling of these parameters to the scale of Belgium and provide the information through the 'Climate Service for Belgium' app.

10.6 ADJUSTMENT OF REGULATION

If needed regulations need to be adjusted to control the introduction and spread of diseases. This can be based upon new scientific evidence resulting in new guidelines such as the case e.g. for cyanobacterial toxins, where both guideline values were adjusted and new toxins were proposed to protect the health of bathers. ***We recommend the revision of the captation and recreation criteria in case of cyanobacteria blooms considering recent guidelines by WHO and US EPA.***

Climate change effects might require adjusted regulation, e.g. in the case of very dry or wet periods, sewage water discharges into surface water should be limited to guarantee good water quality. ***We recommend limiting sewage water discharges into surface in case of very dry or wet periods in order to prevent contamination of surface and groundwater.***

The circular use of water is being promoted in the light of increasing drought, however health effects associated to different ways of reuse of water have not been studied so far. ***We recommend the establishment of a legal framework for the safe reuse of water in the regions, in collaboration with the federal government and European legislation, e.g. the use of surface water for irrigation in urban environments should be regulated. The health consequences of the use of bacterially loaded surface water for crop irrigation must be studied in detail, as currently is performed for cyanotoxins within the Cyantir project.***

For foodborne outbreaks, often a causative agent cannot be determined since only a limited number of microbial parameters is investigated. Food supplements that contain ingredients from natural sources, may contain naturally occurring toxins, this might imply health risks.

10.7 CONTROL MEASURES

Control measures are in place for different stressors, however they are not implemented in the same way across the regions. It would be beneficial to set up a common system for Belgium:

The eradication of exotic mosquitoes, being a regional responsibility, is carried out in all regions, however there is no common approach in the control strategy. ***We recommend to set up a common mosquito control plan in the regions.***

Ragweed control measures are currently being implemented in the Walloon region, in Flanders and Brussels there is no active control policy for ragweed. ***We recommend to set up a common ragweed control plan in the regions.***

Regarding the emergence of the allergenic fungus *Cryptostroma corticale*, no control measures against the maple bark disease have been structurally set up at national level. ***We recommend to set up common control measures for allergenic fungus Cryptostroma corticale.***

All regions are setting up test projects for controlling cyanobacterial algae blooms. Collaboration and exchange of good practices is essential to achieve the most effective and sustainable control measures. ***We recommend sharing of good practices on control measures for cyanobacteria blooms between authorities and research centres***.

10.8 SPATIAL PLANNING – GREEN AND BLUE SPACES

The installation of green and blue spaces at the local scale and the regional scale offers benefits for human health by providing cooling and mental restoration. Its water-buffering capacity reduces the risk of flooding and drought. All local energy climate plans promote the installation of green and blue infrastructure both in the public and private domain, also at regional level measures are being taken. However adapted management of green spaces, specifically in urban areas, in the light of climate-related health effects has not been implemented yet, we give some examples:

- In relation to aeroallergen exposure, a careful tree species selection can establish hypoallergenic green spaces. In this respect it is important to consider increased allergy risks

associated with longer pollen seasons, increased pollen allergen potency, increased sensitization for one or more species in the light of climate change.
- As green and blue spaces serve as habitats of vectors, the possible increased risk for vector-borne diseases should be considered as well as diseases related to exposure to water.

Access to green and blue spaces should be guaranteed also for more vulnerable people, the distance between the home location and the green space is an important parameter and should be kept minimal. The possibility of recreation and social contacts must be promoted through the provision of resting, playing or sporting areas. The aspect of gentrification is not addressed in the plans but is an important aspect in terms of socio-economic equity.

We therefore recommend further greening of public and private domain. In the spatial development of green and blue spaces following aspects are taken into account: careful tree species selection to create hypoallergenic spaces, management measures for ticks, mosquitoes and water, access for vulnerable groups, possibilities for recreation and social interactions, gentrification.

10.9 RESEARCH NEEDS

Exposure to heat, air pollution, and pollen are associated with health outcomes, including cardiovascular and respiratory disease. Studies assessing the health impacts of climate change have considered increased exposure to these risk factors separately, though further research is required for the health impact of **multi-hazards** as they act synergistically on health. Indeed, there is increasing evidence that because of longer exposure to higher amounts of more potent allergenic pollen, sensitization rates for the major tree pollen allergens have increased, as well as the frequency and severity of pollen-induced allergy, asthma, and respiratory disease. ***We recommend further research on the effects of multi-hazards exposure on health.***

In the survey, medical doctors active in psychiatric hospitals point out that more research is required on the impact of heat on the effectiveness of **medication for psychological symptoms**. This contrasts to the relatively well studied impact of heat on medication treating somatic symptoms. ***We recommend further research on the impact of heat on the effectiveness of medication for psychological symptoms.***

While pollen and pollen-carrying species are monitored in Belgium, improvements in allergen characterisation could advance insights in allergenicity and related diseases. ***We recommend research on improved allergen characterization and alignment of treatments.***Extended research will be necessary to fill the large knowledge gaps not only on the known allergenic pollen and fungal spores but on the exposure of the airways to all types of **bioaerosols** (bio-exposome), the identification of their health impacts, either as direct effect, additive or synergistic effect, as connected with multiple allergic/non-allergic diseases and for risk populations. It is also crucial to focus investigation on bioaerosol exposure in the context of climate change, by detecting for newly emerging bioaerosols, further evaluating the changing exposure seasons and severity, altering health outcomes like airway immune deficiency, compromise of the immune system, sensitization to non-pathogenic bioaerosols, symptomatology, and their relation to single/multiple exposures. ***We recommend further research on bioaerosols and their health impacts.***

Climate change has an impact on mycotoxin contamination of cereal grains. Food supplements made from natural ingredients might contain natural toxins, this is currently under investigation for food supplements produced by microalgae or cyanobacteria. ***We recommend to investigate and monitor adverse health effects of natural toxins.***

The effects of climate projections on the **indoor environment** has been studied well from an energy efficiency perspective, however the monitoring of the indoor climate nor the simulation of the impact of climate change on indoor human comfort has not been performed intensively. However the quality of the indoor environment is important for health as people living in a temperate climate such as in Belgium, and especially elderly, typically spend about 90% of their time indoors. In analogy to the dynamic activity-based assessment of exposure to air pollutant, the consideration of both indoor and outdoor thermal stress is important in health impact assessments. ***We recommend further research on the coupling of climate models with indoor environment, especially in the context of thermal comfort.***

10.10 INDICATORS FOR MONITORING

Indicators are indispensable in order to monitor of implementation and effectiveness of adaptation measures. Indicators making use of health data as well as of environmental data are needed in this respect.

An overview of the recommended adaptation actions is given in Appendix B.

11. CONCLUSIONS

In Belgium, climate change is expected to induce hotter and dryer summers and milder and wetter winters. Heatwaves, flooding and drought appear to constitute the main share of climate hazard. Mitigation measures are essential to limit global warming and climate change. At the same time, adaptation measures are time essential to reduce the impact of the consequences related to climate change. Climate related health effects come in many forms. Firstly, the direct health impacts from weather extremes such as high temperatures and heat waves, floods, storms, are visible in figures of mortality and injuries or morbidity effects. Secondly, climate change is altering ecological and environmental conditions, and some areas are becoming more suitable for various infectious diseases. This results in ecosystem-mediated indirect health impacts such as vector-, food- and waterborne diseases, respiratory diseases due to increasing air pollution, exacerbation of allergic reactions due to pollen. Thirdly, there are indirect health impacts linked to occupational health and stresses to mental health and well-being. Currently in Belgium, the health sector is not represented within the multi-institutional structures working on climate change, mitigation and adaptation. However health systems must therefore be increasingly strengthened so that they remain effective in improving the health of the population, including of the most vulnerable groups, in an unstable and changing environment. In this study we assessed the climate-related risks for the healthcare sector and current or planned adaptation plans, in order to recommend further adaptation options. We combined a literature study with interviews and an online survey conducted with different stakeholders of the health sector.

At present, exposure to heat causes the largest climate-related burden of disease. But the (health)care sector should be aware of the advent or increase of other climate-related pathologies and the increase of extreme weather situations (e.g. flooding, drought, wildfire). **Vulnerability** to these hazards in Belgium is enhanced given the large proportion of urban areas, which exacerbate the adverse effects of heating (urban heat island effect) and flooding (impermeable surfaces). It is expected that groups within society that already today exhibit vulnerability (e.g. elderly, people with multi-morbidity and chronic diseases, low income, or inadequate housing), are often also the most vulnerable to climate change effects.

The monitoring and availability of climate projections of **stressor data** is often not optimal, the further deployment is recommended for wildfire risk mapping, drought mapping, high-resolution flood data, permanent monitoring of native and exotic mosquitoes, extended monitoring of bathing water, ragweed monitoring.

Concerning the **health impact** of climate-related stressors, surveillance of heat-related excess mortality is in place. The regional health authorities are responsible for the monitoring of notifiable infectious diseases, Sciensano coordinates the network of sentinel GPs, laboratories and the National Reference Centres for surveillance of epidemiological trends. For emergency service, hospitalization, GP and medication data, it is recommended to set up retrospective analyses and possibly surveillance of heat- and allergy-related morbidity. In this way one can establish the burden of disease attributable to climate-change.

Adaptation measures are best developed for heat, but also exist for other stressors. The federal and regional governments provide advice for implementation at the **local level**, there is specific advice for vulnerable groups. For the set-up, implementation and evaluation of local adaptation measures, it is recommended to set up a governance structure at the (supra-)local level to create a platform with all stakeholders in the domains of social care, health care, wellbeing, spatial planning, environment and health, education, etc. In this way a local climate-health plan can form a basis for many current and future (urban) development projects, realizing health in all policies. We recommend identifying at a regular basis vulnerable groups and their social networks in order to develop communication strategies.

Adaptation measures during heat episodes are well in place in almost all **healthcare facilities**, except for facilities for people with disabilities and rehabilitation hospitals. We recommend the compulsory set-up of heat-health action plan for all residential care facilities and hospitals. Extra financing is needed for the development of sustainable action and personnel management plans during crises, as well as for the implementation of adaptation measures in the infrastructure to create a healthy environment. Structures for knowledge sharing within the healthcare sector are in place, but the information flow from the surveillance and meteorological organizations to the medical practice is not optimal. We recommend streamlining communication channels and the establishment of a clear point of contact. In order to test the resilience of healthcare facilities the set-up of a protocol for stress testing of healthcare infrastructures is recommended, in the scenario-based exercises new risks as well as cascade effects need to be included.

Concerning adjustment of regulation, we made recommendations concerning cyanobacteria blooms as well as sewage water discharge in surface waters.

Control measures are proposed for mosquitoes, ragweed and cyanobacteria.

Nature offers great possibilities for adaptation to heat (by providing shade), to water (by water buffering capacity) and to mental health (social contacts, recreation). We therefore recommend further greening of public and private domain. In the spatial development of green and blue spaces following aspects should be taken into account: possibilities for recreation and social interactions, careful tree species selection to create hypoallergenic spaces, management measures for ticks, mosquitoes and water, access for vulnerable groups, gentrification.

APPENDIX A

Table A-11-1. Overview of healthcare facilities and stakeholders that participated in the interviews

Region	***Organization***
FL	WZC Sint-Godelieve
BRU	WZC Résidence La cambre
FL	Wit-Gele Kruis
FL	Viro VZW
FL	Inkendaal Revalidatieziekenhuis
FL	AZ Geel
FL	ZNA
WA	CHR Namur
FL	Openbaar Psychiatrisch Zorgcentrum Rekem (OPZC Rekem)
WA/BRU	UZ Brussel
FL	Zorgnet-Icuro
WA/BRU	Unessa
FL	Domus Medica
FL	VGWC (Vereniging voor wijkgezondheidscentra)
FED	ACOD
BRU	Observatorium Gezondheid & Welzijn
FED	FPS-Health - MEDEX
FED	FPS-Health - Saniport
FED	FHS Health - PHE Risk Management Group
WA	AVIQ (Observatoire wallon de la Santé)
FL	Academisch Centrum voor Huisartsgeneeskunde, KU Leuven
FL	Dienst stadsontwikkeling – afdeling klimaat en leefmilieu, stad Antwerpen
FL	Dienst milieuhandhaving, stad Antwerpen

Table A-11-2. Descriptive statistics of the online questionnaire [(1)].

Category		Total responses	Total healthcare institutions [(1)]
All		117	133

Category		Percentage of responses	Percentage of healthcare institutions [(1)]
By community	Flemish	78%	70%
	French	22%	30%
By type of financing	Private	67%	67%
	Public	18%	18%
	Public-private partnership	3%	3%
	Other	13%	13%
By type of institution	General hospital	20%	19%
	Academic hospital	2%	2%
	Psychiatric hospital or care institution	7%	10%
	Institutution for persons with a disability	38%	35%
	Elderly care home	27%	29%
	Rehabilitation hospital	2%	3%
	Other	3%	3%

Note: [(1)] Several responses from the the French-speaking community group responses from multiple care institutions which fall within a group of healthcare organizations. When identifying the individual care institutions, the distribution then changes.

APPENDIX B

	Theme	Aspect	Recommendation
1	Climate	Data, research	Establishment of new high-resolution projections for Belgium making use of CMIP6-climate data, for general climate parameters as well as for health-, drought-, flooding-, wildfire-related indicators.
2	Climate, health	Research	Research on the coupling of climate models with indoor environment, especially in the context of thermal comfort.
3	Climate, health	Communication	The development of a Belgian Centre of Excellence on Climate could provide a forum for collecting scientific expertise and knowledge both at national and international level, facilitating the dialogue with stakeholders of various regions and sectors such as healthcare, energy, environment, etc.
4	Climate, health	Policy, data, risk management	The development of a national health and climate change plan, which considers health risks of climate change as well as of adaptation and mitigation measures, and which assesses health resilience to climate change.
5	Vulnerability	Data, monitoring, research	Assessment of the vulnerability of the Belgian population at the level of a statistical sector, making use of publicly available datasets based on e.g. census data. Development and application of a methodology for local assessments (resulting in homogenous data).
6	Health	Data	Availability of (near-) real-time health data from emergency services, hospitals, general practitioners, laboratories, medication use, etc. both on physiological and mental health.
7	Health	Data, monitoring, research	A retrospective analysis of health data can determine the burden of disease for various climate-related stressors such as heat (but also allergy, ticks, flooding, etc). Sensitivity analyses on parameters such as age, urban population, socio-economic status, etc. can be performed to determine vulnerable groups in the population. A surveillance or monitoring system can be put in place, this can be used as activation criteria of e.g. heat-health plans. Remark: this requires the availability of health data.
8	Heat, health, vulnerability	Data, research	A heat-related vulnerability assessment using mortality and morbidity data.
9	Heat, flooding, storms	Monitoring, forecast, risk	Set-up of high-resolution weather monitoring and forecasting system, especially for urban areas

		management	
10	Heat, health, vulnerability	Policy, risk management	Investigation of other activation criteria for ozone-heat plans such as minimum temperature as well as the use of local forecasts, especially for warning urban dwellers (UHI). The retrospective analysis of mortality and morbidity data could be used in the assessment. The results of this analysis could also highlight (health) indicators for which real-time information through surveillance can guide the activation of health action plans/alarms.
11	Heat, health, vulnerability	Policy, action plan	Inclusion of specific actions for obese people, pregnant women, workers, drug users, homeless people in ozone-heat plans. More attention should be given to the effects of medication in the general sections dealing with vulnerable subgroups (currently missing or only in detailed sections for care workers). Inclusion of health effects due to UV radiation as stressor and measures are the same.
12	Heat, health, healthcare facilities	Policy, risk management	Compulsory set-up of heat-health action plan for all facilities and hospitals, both residential and non-residential (including child care facilities, schools, shelters for the homeless, drug rehabilitation centres, etc.).
13	Health, local	Policy	Set-up of a governance structure at the (supra-) local level to create a platform with all stakeholders related to climate, social care, health care, education, spatial planning, etc. Further development of community-based care initiatives and increase surveillance (e.g. by telephone, visit) of vulnerable people at home during extreme weather events.
14	Local, vulnerability	Communication	Regular identification of vulnerable groups and their networks in order to develop communication strategies.
15	Heat, flooding, drought	Green & blue	Further greening of public and private domain, to provide shade and cooling and to reduce the risks of flooding and drought. An important aspect is that recreational green and blue spaces should be easily accessible for vulnerable groups and offer infrastructure (e.g. resting bank, playing area, sports area, etc.) for recreation. The aspect of gentrification should be taken up in planning.
16	Vector-borne	Policy, monitoring	Set-up of an adequate governance structure to continuously monitor (preferentially both native and) invasive mosquito species.
17	Vector-borne	Policy, monitoring	Extension of existing active and passive monitoring programmes for exotic pathogens in wildlife and investigation of pathways of their introduction.
18	Vector-borne	Green & blue, control	Management measures for ticks and mosquitoes in spatial green & blue planning.

19	Vector-borne	Communication	Sensibilization campaigns on vector-borne diseases should also address vulnerable groups such as professionals working in nature (ticks) and travelers (mosquitoes).
20	Vector-borne	Policy, control	Set-up of a common mosquito control plan.
21	Water-borne	Policy	Limitation of sewage water discharges into surface in case of very dry or wet periods to prevent contamination of surface and groundwater.
22	Water-borne	Monitoring	To protect bathers against infections with viral and protozoan parasites that persist longer in water, it is recommended to perform research to determine the added value of monitoring coliphages.
23	Water-borne	Monitoring, control	Sharing of good practices on monitoring (including bloom models) and control measures for cyanobacteria blooms between authorities and research centres.
24	Water-borne	Policy	Revision of the captation and recreation criteria in case of cyanobacteria blooms, considering recent guidelines by WHO and US EPA.
25	Water-borne	Communication	Sensibilization campaign for general public and e-learning modules for GPs in order to better assess the health effects of food- and water-borne infections.
26	Water-borne	Monitoring, communication	For better surveillance of health complaints with respect to water quality for bathing, a questionnaire system could be developed, with a digital questionnaire sent at the end of the bathing season requesting local health departments and provinces to enter the bathing water related health complaints they have received/noted. That information can be compiled into an annual surveillance overview and communicated to stakeholders
27	Food-borne	Monitoring	An alert system based on the monitoring of the number of foodborne outbreaks of unknown causative agents could identify a possible trend in an early stage. This alert would dictate further investigation (retrospective or future oriented monitoring).
28	Food-borne, water-borne	Monitoring, data	To facilitate data collection and information gathering, citizens can be encouraged to report their symptoms via an app or social media channels. A similar reporting system could be set up for estimation of the incidence of water-borne diseases.
29	Food-borne	Data, research	More research is needed to investigate adverse health effects of natural toxins.
30	Water-borne	Policy	A legal framework for the safe reuse of water must be set up in the regions, in collaboration with the federal government and European legislation, e.g. the use of surface water for irrigation in urban environments should be regulated. The health consequences of the use of bacterially loaded surface

			water for crop irrigation must be studied in detail, as currently is performed for cyanotoxins within the Cyantir project.
31	Pollen, allergies	Data	Set-up of relevant and homogeneous protocols of clinical data collection in relation to specific allergic diseases. This requires the data-availability of emergency department visits, hospitalization, general practitioner and medication data.
32	Pollen, allergies	Research	Improved allergen characterization and alignment of treatments.
33	Pollen	Monitoring, control	Set-up of monitoring and control for emerging and/or exotic species with known allergenic potency (e.g. ragweed in Flanders and Brussels, fungus Cryptostroma corticale in Belgium).
34	Pollen & spores	Research	Research on new allergenic plants and spores, their pollen production and sensitivity of population under climate scenarios, combined exposure to pollen and air pollution.
35	Pollen, allergies	Green & blue	Establishment of hypoallergenic green spaces through careful tree species selections (considering climate related effects).
36	Pollen	Monitoring, forecast	Transition and standardization to automatic real-time bioaerosol monitoring. Development of operational bioaerosol forecast systems (short-term prevention, long-term climate scenarios).
37	Heat, mental health	Data, research	Assessment of the effects of heat on mental health in the Belgian population.
38	Vulnerability	Communication	Intense surveillance (e.g. by telephone, home visits) of vulnerable people at home during extreme weather events.
39	Heat, health	Research	Research on the impact of heat on the effectiveness of medication for psychological symptoms.
40	Climate, vulnerability	Research	Research on climate anxiety and into which groups are most affected is needed to develop effective interventions against it.
41	Healthcare personnel & infrastructure	Financing	Increase financing of entire (health)care sector, including health promotion and prevention programmes.
42	Healthcare, local	Policy, financing	Roll-out of health management systems and local organization of home- and community-based care.
43	Healthcare personnel	Communication, financing	Financial compensation to focus more on trainings for health promotion and prevention. Initiatives related to good practice sharing of adaptation measures, for example in existing structures of environmental coordinators, prevention advisors, etc.

44	Health, extreme weather, Healthcare personnel	Communication, risk management	Streamline communication channels from surveillance and meteorological organizations to medical practise (as well as general population including vulnerable groups). The information should be tailored specifically to the needs of the (possibly different types of) receivers, this might involve the set-up of a multisectoral organ. The establishment of clear points of contact is especially important during crises.
45	Healthcare personnel	Action plan, risk management	Development and implementation of sustainable action and personnel management plans during crises, especially heat-related, compulsory for residential care facilities and hospitals.
46	Healthcare personnel	Policy, risk management	Establishment of legal framework for implementation of current measures (and others, e.g. list of reserve doctors) concerning surge capacity in future health crises, increase flexibility between different lines.
47	Healthcare infrastructure	Guidance	Provision of technical guidelines (not additional legislation) and means of application related to energy efficiency, cooling and ventilation etc., for use specifically in the healthcare sector.
48	Healthcare infrastructure	Guidance, Green & blue, financing	Elaboration of VIPA- and UREBA-programmes for adaptation measures, including green and blue infrastructures to create healthy environments.
49	Healthcare infrastructure, extreme weather	Data, risk management	Identification of energy needs of non-critical healthcare infrastructures in crisis situations.
50	Healthcare infrastructure	risk management	Establishment of long-term climate-resilience action plan for healthcare infrastructure.
51	Flooding, storms	Monitoring, forecast, risk management	Promotion of set-up of detailed high-resolution risk maps for flooding, using hydrological modelling with detailed local data.
52	Flooding, storms	Research, risk management	Exploration of use of X-band radar precipitation data in hydrological models for high-resolution flooding forecast.
53	Wildfire	Monitoring, forecast, policy	Set-up of an adequate governance structure to establish and regularly update risks maps for wildfire, as well as for monitoring and forecasting (considering dynamic data on fire ignition and propagation).
54	Healthcare infrastructure, extreme weather	Risk management	Extension of HEP and internal emergency plans to account for longer, more severe hazards, including cascade effects.

55	Healthcare infrastructure, extreme weather	Risk management	Appointment or strengthening of function of emergency coordinator, training of emergency plans.
56	Healthcare infrastructure, extreme weather	Risk management	Set-up of protocol for stress testing of healthcare infrastructures, including new risks as well as cascade effects in the scenario-based exercises.
57	Climate, health, extreme weather	Communication	Set-up of a central website/app ‘Climate Service for Belgium’ including basic climate parameters as well as sector-specific derived indicators (e.g. high-resolution climate projections on drought, flooding, wildfires, apparent temperature).
58	Climate, health, extreme weather	Communication	Upscaling of local/regional climate-health services to the scale of Belgium and provide the information through the ‘Climate Service for Belgium’ app.
59	Climate, health, extreme weather	Research, communication	Further deployment of citizen science initiatives to derive evidence-based local information but also to create awareness amongst the participants and general population.
60	Climate, health	Data, research	Dedicated research is needed to assess the current & future burden of disease related to climate-change (for heat, allergy, ticks, flooding, etc.), time-series of annual data could be set up and compared to the burden by other environmental stressors.
61	Climate, health	Monitoring	Set-up of climate-health indicators to assess the evolution of hazard, exposure, vulnerability, impact and the effectiveness of mitigation and adaptation measures.

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