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Dealing with high temperatures: A survey assessing the degree of heat risk awareness and the adaptation measures applied in hospitals and retirement homes in Berlin

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Abstract

Objectives: In particular vulnerable individuals have to cope with a changing climate, already now and increasingly in the future. The aim of this study was to assess the degree of heat risk awareness and adaptation measures applied in hospitals and retirement homes in Berlin.

Methods: In a multi method approach a survey was developed and were sent to the care managers of all eligible stationary healthcare providers (HCP) in Berlin (N=357). The survey included questions on the presence of a heat action plans and cooling management facilities in the buildings. Furthermore, the care managers were asked to judge the importance of measures against heat related health risks, and to report practical problems that may affect the implementation of heat reduction measures. In addition, experts in this field were asked to report strategies that increase the awareness and the adaptation measures in hospitals and retirement homes in Berlin.

Results: Of the 357 questionnaires sent, 35 were returned (13%). Strong associations between the increase in patient care during high temperatures and the increase of requirement of health care staff during those days could be statistically determined ($r = .567$, $p = .001$, $n = 34$). Association between heat risk awareness and heat risk adaptation could not be observed ($F [1.24]= 1.563$; $p = 0.223$). Most HCP had not a heat action plan. Sunshades were used most often to protect patients/residents against high temperatures (99% of all HCP). Prevalence of cooling facilities such as air conditioning and rooftop greenings are very low (2-5%). Care managers confirmed the importance of heat risk adaptation measures, with some exceptions. Barriers of heat action implementation mentioned related to building structure, storage among health care personnel and a lack of policy support of heat reduction measures.

Conclusion: In general the implementation of heat adaptation strategies are rather on a sufficient minimum level. However, HCP are aware of heat related health impacts of their patients or residents and staff. Further development and implementation of heat adaptation is essential to protect the institutionalized patients and residents against future increase of high temperatures. Potential areas of improvement include the cooling of buildings and training of staff.

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“Whoever wishes to investigate medicine properly, should proceed thus: in the first place to consider the seasons of the year, and what effects each of them produces, for they are not all alike, but differ much from themselves in regard to their changes.”

Hippocrates, in Airs, Waters, and Places (18)

1 Introduction

1.1 Definition of the problem

Berlin, Monday the 29th of May 2017. From a meteorologically point of view it is the end of spring. The heat warning system of the German Weather Service (DWD) announced a heat alarm for Berlin and Brandenburg. The temperature rises up to 32°C and the meteorologists estimates a perceived heat load of about 33°C for Berlin citizens. The headline of the Berlin newspaper report*: "Heat record: Berlin gets up to 32 degrees! Hotter than Miami".* The public authorities spread information about adequate behaviour due to heat: *"Visitors who want to join the street parade -Karnevall der Kulturen- should be aware to protect their head today. Citizens that are vulnerable to high temperatures should drink more than usual and parents should not leave children alone in their cars".*

The scientific community already focused on international and national level on the heat related environmental health risks in last centuries and investigated the impacts of heat stress on human health.[1] [2] [3] Due to climate change extreme heat is one of the challenges already humans have to deal with now and very likely in the future.[4] Correspondently, the demands for healthcare providers will increase due to climate change. There are rages of hazards that possibly influence the processes and lead to serious health risks for patients and residents in health care facilities during hot days.[5] For instance, if the urban energy infrastructure is over-stressed; the electrical grid is challenged to provide sufficient energy to meet residential and commercial cooling demands. As a result, rolling electrical blackouts often accompany extended heat waves, which can compromise health care delivery.[6] On the other hand urban hospitals often have to shift to emergency power generation in order to free grid resources during peak demand periods. Corresponding elevations in humidity can overwhelm cooling tower and chiller capacities. This is a particular concern in operating rooms where ventilation is essential to prevent patient infection via airborne pathogens.[7] Many hospitals do not have their cooling systems on their emergency power generation systems. When blackouts occur, hospitals are require continuing to operate their basic ventilation systems but may lose portions of their space cooling systems. For the most part, hospitals are sealed buildings, i.e. they do not incorporate operable windows due to infection control and pressurization requirements.

In addition, sociocultural developments such as changes in life conditions in urban areas, the increase in urban population, the demographic change, the increases in socioeconomic disparities and in chronic diseases enhance health risks and tasks in health care issues.[8]

Perceived heat load and an increase of high temperatures already observed over the resent years in Berlin.[9] In the year 2013, a total of 12 heat warning days occurred from a temperature of 32°C in 3 periods during the summer months of June, July and August. The daily maximum air temperature between the heat warning days did not decrease less than 25°C. During these days, several federal states in Germany register an increase of hospital admission up to 10%. In the heat summers of 2003, 2006 and 2010,[10] which were characterized by long-lasting summers significant mortality rates in the whole European region occurred. In the summer of 2003 more than 70,000 people died especially in the countries of the Western and Central Europe due to heat stress.[11] In 2003 Paris experience the consequences of a heat wave and reveal a 130% increase in expected mortality.[12] The Assistance Publique – Hôpitaux de Paris reported more than 2600 excess emergency department visits, most of them classified as heat related, and 1900 excess hospital admissions, which unfortunately coincided with a common decrease of available beds during the summer period.[13] HCP like the hospital Avicenne near Paris, announced that the medical team had worked eight days without respite and was exhausted. French officials blame the high death toll in part on the length of the heat wave and the fact that Parisian buildings typically lack air conditioning.[13]

The introduced case of Paris shows that an increasing urban population leads to an increasing number of people being threatened by heat stress in the built-up environment of cities. High temperatures in major cities such as Berlin possibly causes significant negative environmental and economic impacts, e.g. on thermal comfort and, more seriously on the health of the citizens.[14]

Heat-related illnesses are more frequent in elderly people, especially those who live in urban areas. The increase in mortality caused by high temperature is not limited to individuals residing in private or nursing homes but also among those in hospitals.[8] If a proportion of heat related mortality occurs among already hospitalised people,[15] public health activities during heatwaves should not be concentrated solely on susceptible populations at home but also towards people who are already under medical care in hospital or retirement homes.[16]

HCP have duties to protect human's lives. Episodes of extreme temperature can have significant impacts on health and represent challenges for divers group of expert's e.g. public health, civil protection services, HCP and urban development.[17] It is therefore urgent that researchers and practitioners take appropriate measures in responding to this threat. HCP perceptions and thoughts about their role of heat adaptation remain little explored with existing work focusing mostly on public health officials[18]. Therefore, it is important to investigate to what extent stationary HCP are aware and adapted of the heat related health risks for the individuals who are already in hospital or in retirement homes during frequently days of high temperatures.

Recent social science points out the gap between an ever increasing number of publications on climate change adaptation, but little implementation of risk reducing measures in practice.[19] [20] This lack of evidence towards increasing health risks, especially in cities such as Berlin where the urban heat island effect[1] intensifies extreme heat events are determined by the urban development itself.[21] Therefore this study want to investigate how HCP in major cities in Germany, such as Berlin, cope with heat-related risks with regard of operational, structural and environmental challenges at their organisation.

[1] Urban heat island effect (UHI): built up areas that are hotter than nearby rural areas, as a result of the unprecedented growth in urbanization. The process of urbanization natural landscapes, like cropland and forests, are transformed into impervious surfaces consisting of chemical materials that effectively store short-wave radiation, such as cement, metal, and asphalt.[173]

1.2 Objectives and Research Question

In general this study wants to investigate the heat risk awareness of stationary HCP due to high temperatures in Berlin, Germany. Aim of this scientific work is to establish a tool that makes it possible to measure the heat risk awareness of stationary HCP with regard to the environmental hazard of high temperatures. Enhanced attention this research wants to determine if there is a correlation between the level of heat risk awareness and modalities of adaptation strategies against the climatic circumstances of an increase of days with high temperatures in Berlin per year. The results of the gained scientific knowledge should serve as baseline for the development of climate adaptive solutions for HCP to cope with an increase of high temperature days in Berlin.

The objectives of the study are subdivided into a general objective and specific objectives:

General Objectives

- To investigate how stationary HCP in Berlin cope with the issue of health related risks of their "clients" (patients/residents) due to an increase of high temperatures.

Specific Objectives

- To develop a robust survey to assess the heat risk awareness and adaptation measures of HCP in Berlin regarding to high temperatures.
- To identify current procedures, strategies, knowledge and environmental factors (such as building design and cooling equipment), used in stationary healthcare institutions in Berlin.
- To provide evidence which heat adaptation strategies can be developed and implemented in stationary health care settings which may be adapted to prevent morbidity and mortality of patients/residents associated with heat.

This investigation is triggered by the following research questions:

- Are the stationary HCP aware of the health risks of their clients caused by high temperatures?

- How do stationary HCP assess their knowledge about the impact and threat of heat related health risks?
- Do stationary HCP have implemented heat adaptation measures to cope with health risks of their clients regarding to high temperatures?

1.3 Hypothesis

The first hypothesis assume that effective responses to hot temperatures requires an understanding of the impact on health and well-being, and the risk or protective factors within patients or residents.[22] Therefore we estimate, if the awareness of HCP due to heat related health risk for patients and residents is high, the adaptation strategies of HCP to mitigate high temperatures are sufficiently implemented.

1) H1: The higher the heat risk awareness of HCP (determined score of heat risk awareness), the better availability of heat adaptation strategies in HCP facilities (determined score of heat adaptation).
   H0: The higher the heat risk awareness of HCP (determined score of heat risk awareness), the worse availability of heat adaptation strategies in HCP facilities (determined score of heat adaptation).

The second hypothesis is the easiest to understand. If the stationary HCP recognise an increase in patient care during hot days (30C), the working conditions of health care stuff will change. This situation implies an additional work load for health care stuff during their shift work. It is known that working conditions have an important impact on job satisfaction and a high workload is associated with a lower performance at primary care practices[2]. As a result of high demands to care for health care professionals during hot days it can be expected that stationary HCP also determine an increased need to recruit health care staff during those days.

2) H1: Stationary HCP that recognize an increase in patient care during hot days (30°C) also determine an increased need to recruit health care staff during those days.
   H0: Stationary HCP that recognize an increase in patient care during hot days (30°C) do not determine an increased need to recruit health care staff during those days.

1.4 Concept of the Research

The study is based on a cross-sectional mixed method approach with both quantitative and qualitative parts. We conducted an extended systematic literature research by using the RRISMA approach to gain a specific insight into the research subject. Semi-structured interviews by using the interview technic “think-a-loud” was applied with stake holders such as, physicians, climate experts, architects for healthcare facilities, urban planners and other experts in this flied of research.[23] The results were conducted by content analysis according to Mayring to generate innovative heat adaptation recommendations.[24] To assess the status que of heat awareness and adaptation of HCP we developed a survey. The stakeholders evaluated a first draft questionnaire. Furthermore a weighted heat risk awareness- and a heat adaptation index was developed. After these steps the final questionnaire was distributed to the HCP. Quantitative analysis was conducted by using SPSS Version 22.

2 State of the Art

This chapter will give a brief insight into the relationship between the environment conditions such as climate change and human health. We want to show the political dimension in the context of climate change. In particular, we will give an overview about the current scientific knowledge due to increased temperatures and the related health impacts in Berlin.

2.1 Environment and Health in the Context of Climate Change and the Urban Climate

- International Level

The importance of climate change on human health has often been discussed by scientific research, economics, politics, urban planning, media and also in society. The direction of political international level regarding the impact of climate change and adaptation strategies due to the protection of human health is many discussed by the Intergovernmental Panel on Climate Change (IPPC) and the World Health Organisation in cooperation with research institutions and authorities. Together they develop and publish information on scientific community research and projections concerning climate change.[25] [26] [27]. With the adaptation of the Climate Agreement at the Climate Change Conference (COP) in Paris in December 2015, the international community agreed for the first time on a binding set of rules to keep global warming well below 2°C compared to pre-industrial levels. Countries shall also endeavour to limit the global rise in temperature to 1.5°C.[28] In addition to this, all countries - industrialised countries, emerging economies and developing countries committed themselves to making an appropriate contribution to international climate action.[29]

Historical view of political agreement on Climate Change

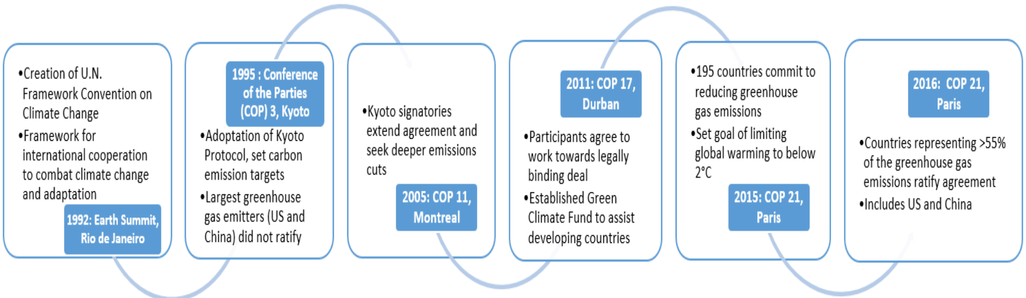

Figure 1: The political history of international agreements on environmental policies and climate change regulations form 1992 till present.

- National Level

On the political national level the Federal Ministry of Education and Research (BMBF), the Federal Ministry of Health (BMG), Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), the Federal Environmental Agency (UBA), the Robert-Koch-Institute (RKI) and the German Weather Service (DWD) in cooperation with other research organisations and authorities are working together on the topic climate and health. [30] [31] [32] [33] [34]

On 17 December 2008 the Federal Cabinet adopted the German Strategy for Adaptation to Climate Change. This creates a framework for adapting to the impacts of climate change in Germany.[35] It primarily describes the contribution of the Federation, thus acting as a guide for other actors. To this end, the German Government adopted the Climate Action Plan 2050 in late 2016.[36] The plan has developed guiding principles for 2050 for all areas of action and illustrates approaches for the long-term transformation. Already in December 2014, the German Government adopted a package of short-term measures with the Climate Action Programme 2020 which will contribute to reaching the next interim target in 2020. This action plan also includes a list of in all national- and local wild additives due to climate change and health.[33]

- Regional Level (Berlin)

Form 2007 till 2011 the Berlin “Climate Protection Advisory Board” was founded to develop issues and tasks about the topic climate change and human health.[37] In 2009 the senate administrations of the city of Berlin have submitted their first local report about climate change in Berlin. Besides other topics of climate change the senate referenced to the health care sector of Berlin. The Senate announced that there is a considerable need for research on the impacts of the Berlin health care sector due to climate change.[38] In 2010 the DWD and the senate administrations of the city of Berlin conducted an investigation about the biological climate under consideration of “Climate Change in Berlin”. This project focused on the investigation to determine the spatial structures and the frequency of future heat load could have an impact on human health.[39] The Potsdam Institute for Climate Impact Research (PIK) had developed a climate impact land register. In this manner one can gather information in a developed cluster that focused climate change impact on human health.[40] From 2013 till 2014 the

Berlin university hospital Charité have had run an educational program for climate change adaptation called “Klimaanpassungsschule” (KAS).[41] This project was implemented as a platform for health agents (GP, Nurses etc.) to gathering information about climate change impacts on human health and provide advice about preventing and caring for patients due to climate change risks.[42]

In 2011 the Urban Development Plan Climate (StEP Klima) was presented by the Senate of Berlin. In 2015/16 an updated version has been worked out, focusing on the specific challenges of Berlin’s recent growth. StEP Klima KONKRET (StEP Climate Concrete) is addressing future climate change under a deliberately space-oriented planning perspective. Since 2016, the Environmental Atlas, Berlin’s map and info server on environmental issues, provides a new climate model (‘Planning Advices Urban Climate’), showing which areas suffer from adverse climatic conditions already today, and where Berlin has capability of relief.[43 21]

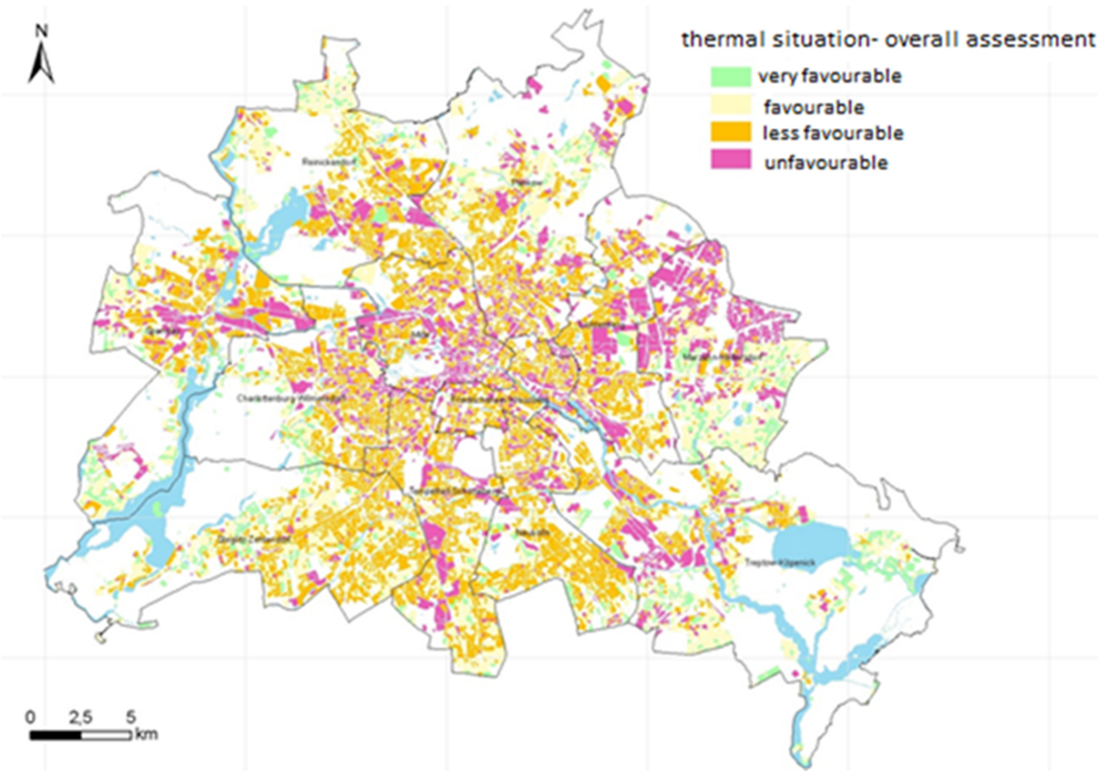

Figure 2: spatial distribution of the thermal characterization due to heat vulnerable areas in the urban area of Berlin (mean measurement night and day). Adapted from SenStadtUm (Senatsverwaltung für Stadtentwicklung und Umwelt Berlin)2014. [44]

2.2 Climate Change Conditions in Berlin

According to the State Statistical Institute Berlin-Brandenburg (LDS BB) from 2012 Berlin covers an area of 892 km2 and has many public green spaces (11 % of the area) and forests (18 % of the area) within its administrative borders. Berlin is located in north-east Germany and lies in the North German Plain. Therefore, it has a rather flat topography, with the Barnim Plateau in the northeast and the Teltow Plateau in the south, flanking the Berlin-Warsaw Urstromtal, a broad valley formed during the last glaciation. The difference in topography amount to a few tens of meters, so topography has only a minor influence on the local climate.[37] The higher parts have slightly increased air temperatures, but the differences due to topography are typically lower than 1 K.[45] Berlin has a temperate climate with characteristics of both oceanic and continental influences. The yearly average air temperature ranged from 7 to 10.5 °C throughout Berlin and the surrounding areas for the period from 1961 to 1990.[46] During the same period, the warmest recorded temperature was 35.8°C, and approximately 32 summers. According to Scherber (2014) the regional area of Berlin is particular at risk because of climate change.[47] Due to a relatively low annual precipitation (560 mm, compared to German average 800 mm), a high amount of water bodies (two thirds of the area) and a particular dominance of sandy surfaces with less storage capacity Berlin is particularly vulnerable to the risks posed by heat and drought periods.[1]

Heat and drought conditions typically results in scarcity of water.[48] According to Koppe and colleges (2004) the agglomeration of Berlin is particular at risk to suffer from heat waves. Agglomerations increase the urban heat islands (UHI) and especially at night this effect causes further heat stress for citizens.[25] An UHI is a metropolitan area which is significantly warmer than its surroundings (rural areas).[49] However, UHIs can also develop in a small scale in the inner city. The temperature differences between urban and rural areas caused by various circumstances for instance the sealed surfaces of urban areas reduce evaporation, thus solar radiation on buildings and road surfaces keep the heat.[50] Furthermore we can observe a trend of an increasing urbanization. Berlin has got 3.67 million inhabitants and expected to grow substantially in the next decade.[51] That might implies higher energy consumption, an increase of air pollution and also lead to more sealed surfaces.[52]

Currently with a mean temperature of 10.5°C (9.1°C) Berlin is the warmest region in Germany with less than 505 l/m² (573 l/m²) rainfall the federal state of Berlin is the second driest and with nearly 1710 sun hours (1635 hours) the second sunniest federal state in Germany.[53] According to the Brandenburg State Environmental Agency (2011) the daily average temperatures already increased by more than 1°C since the beginning of the last century.[40] Based on the regional climate model (STAR2, CCLM, REMO, WETTREG) and under the assumption of the A1B28 SRES scenarios the following future projections can be gained: From 2031 till 2060 the average daytime temperature will increase up to a minimum of 1°C. This results in a transgression of the two-degree-limit in the middle of this century. Till the next century the value of temperature will increase up to 3°C compared to period 1971 – 1990.[39] The sum of the annual precipitation will not change significantly.[54] The vegetation period will be extended by at least 3 weeks. The number of summer days, hot days, sultry days and tropical nights will significantly increase. Controversy colder days (including ice and frost days) will decrease.[55]

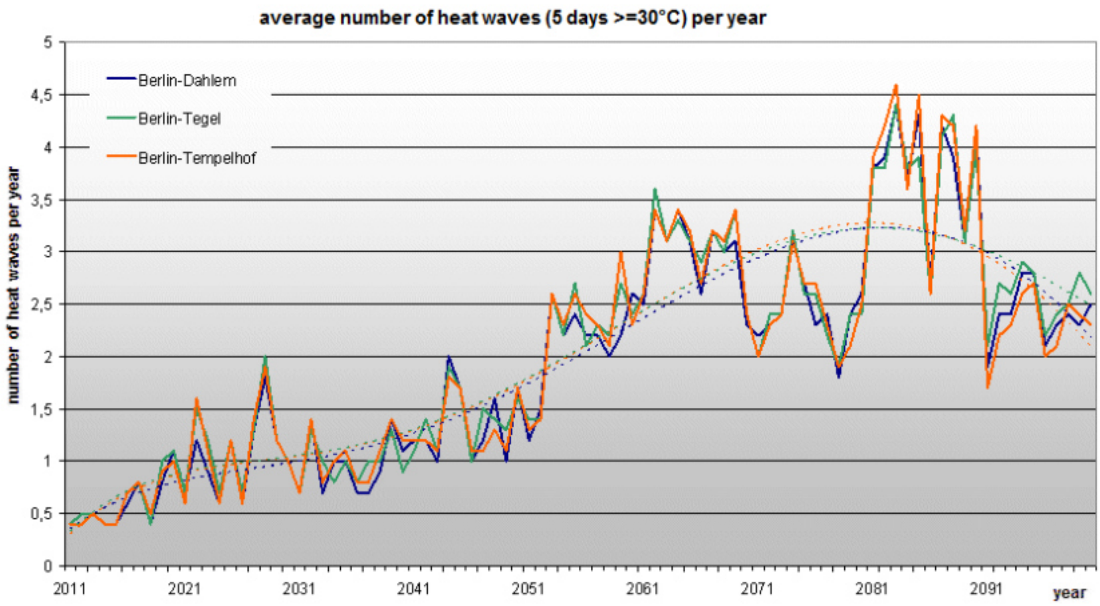

Figure 3: Projection of the average number of future hot waves per year at three Berlin climate stations for the time period 2011 to 2100; WETTREG projection, scenario A1B, (dashed lines = polynomial trend). Adapted from SenStadtUm (Senatsverwaltung für Stadtentwicklung und Umwelt Berlin)2015.[56]

In 2013 the IPCC had published an emission scenario (representative concentration pathway). Due to this projection the federal state of Berlin belongs to one of the areas that have to deal with the highest increase of temperatures, although the protection does not consider the UHI.[57] In 2011 the Berlin ministry for urban development (SenStadt) and the German weather service (DWD) carried out an investigation on the biological climate in the context of climate change in order to determine the spatial structure and frequency of future health-relevant heat stress. [43] On the basis of this data it appears that until the middle of the 21st century a slight but significant and a marked increase in heat stress can be expected until the end of the century.[58] Areas of the inner city which already affected most by heat stress will be intensified affected in the future. By the end of this century, half of the days will be heat stressed in the summer months in those areas. In contrast between rural and inner city "green areas" only expect not quite a third of heat stress [59] [44] [60] A recent study identified a total of 72 heat episodes in Berlin during the period 1891 to 2006.[61] For the 21st century a regional climate model projected 142 heat episodes. In the course of this century the climate in Berlin will be similar compared to the current climate of the upper and central regions of Italy.[38]

2.3 The Impact of Climate Change and Health

Science 1990 the IPCC submitted reports about the impact of climate change on an international level. These reports also cover the demand of research due to the impacts of climate change on human health and mitigation-, adaptation strategies.[62] Urban heat Islands and urban pollution be considered as key characteristics regarding climate chance related health impacts and are important in research for measuring the causal effect.[63] According to the IPCC and the WHO now and very likely in the future climate change contributes to the global burden of disease and premature death word wide.[64] [65] Besides the negative impacts of climate change for human health some climate chance conditions does have a positive impact on the human well-being, such as, the a decrease in cold-related deaths and exposure to cold-associated diseases in milder winters [33] an a increase of well-being due to an increase of vitamin d level and a decrease of rheumatic complaints due to higher temperatures and days of sunshine.[34] However, negative impacts of climate change have a priority in research. In the following Figure 4 the most important pathways are shown.[65] [66]

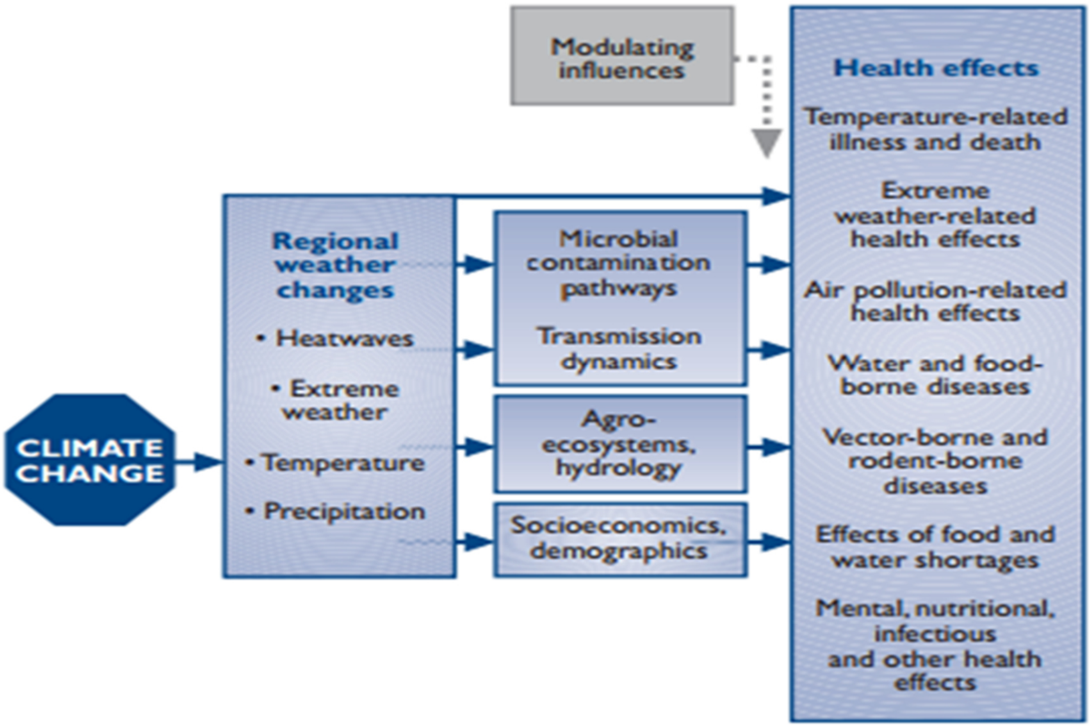

Figure 4: Pathways by which climate change affects human health, including local modulating influences and the feedback influence of adaptation measures. Adapted from Patz and colleges (2000)[67]

The impact of climate change on human health can be differentiated into two types of impacts: [68]

- Direct Impacts: Increased mortality due to heat/cold waves, floods, droughts, cyclones, poisonous gases, and so on.
- Indirect Impacts: Increased health problems due to vectors, contaminated food and water, malnutrition due to reduced food production.

Besides the impacts resulting from direct exposure (e.g. heat waves) and indirect exposure (e.g. water pollution), the socioeconomic disruption also have an impact on human health. According to the IPCC (2007) these effects of climate change do not act in isolation, however; environmental, social, and health system factors modify these impacts substantially.[62 63]

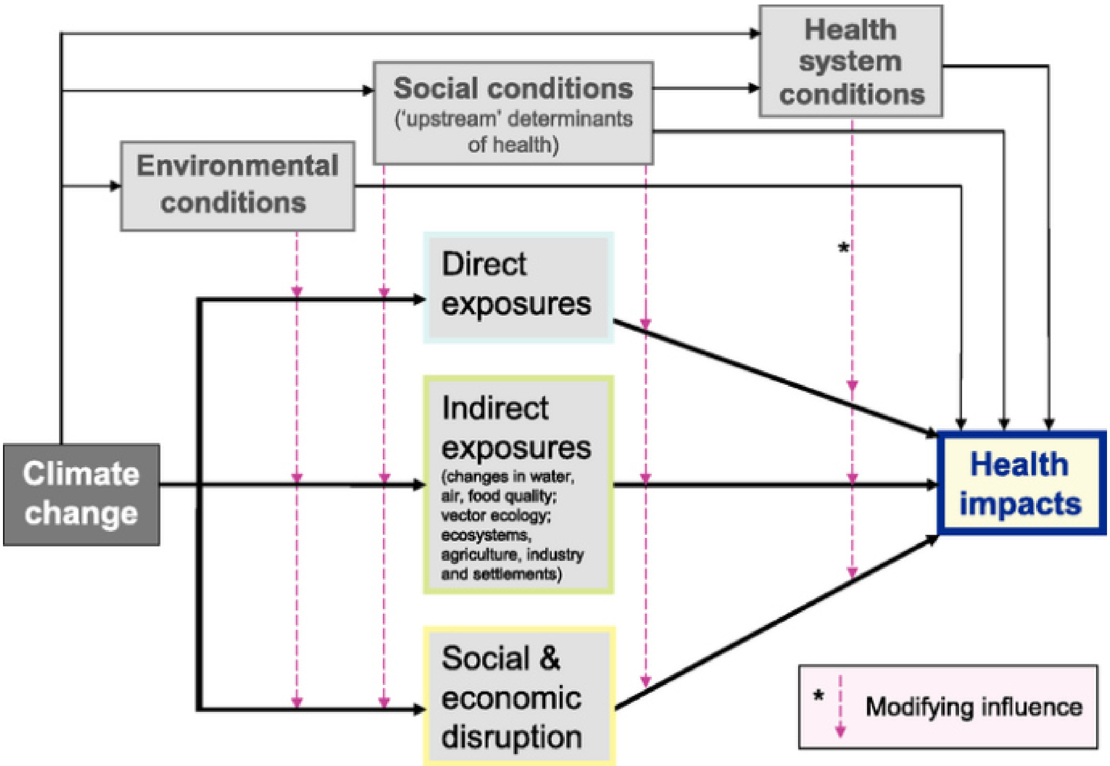

Figure 5: Pathways by which climate change affects health, and concurrent direct-acting and modifying influences of environmental, social, and health-system factors. Adapted from Parry, M. L., et al. (2007).[69]

2.4 The Impact of Heat Stress on Human Health

In general thermal burden differs in heat stress and cold storage.[70] Provided that the average skin temperature and sweat rate are hypothetically held in the comfort area thermal burden is defined as the difference between internal heat production and heat loss of a human being with its current activity level.[25] If both, the temperature and the humidity are high, humans can experience considerable heat stress. Heat stress is considered as a health-relevant assessment of the thermal environment.[71] Variables that have an influence on thermal sensation or the thermal burden are; air temperature, average radiation temperature, humidity, wind speed, heat production of the human (metabolic rate, physical activity), heat isolation of the cloths and the duration of exposure.[70] The description and evaluation of the thermal environment that take these factors into account can be conducted in simple processes, such as. air temperature thresholds, humidex, heat index, or complex methods, like the Predicted mean vote (PMV), Physiological equivalent temperature (PET) or the Universal Thermal Climate Index (UTCI).[72]

Healthy Humans have an extraordinary high level of adaptability due to different atmospheric conditions (acclimatisation).[73] Autonomous regulations provide the adjustment performance for healthy organisms. However, heat can impair the human organism and its physiological processes in various ways, while the organism also interacting with pre-existing conditions and chronic diseases. [74] Both exposures, the primary concern are a change of the body's core temperature beyond a healthy range. A deviation of ± 3.5°C from the resting temperature of 37°C can result in physiological impairments and fatality.[75] According to Sessler (2009) the following processes control the gain or loss of heat (thermoregulatory regulation):[76]

- Conduction- temperature exchange through direct contact with hot or cold surfaces
- Convection- temperature exchange through movement of air or fluid
- Radiation- temperature exchange related to emission and reception of electromagnetic waves
- Evaporation- cooling caused by water from perspiration leaving the skin's surface as a vapour

Heat is created by metabolic processes, tremor-free heat formation, cold chattering and physical movement (M +W). The energy fluxes have a positive sign when it lead to an energy gain of the organism and a negative sign when it lead to a loss of energy.[70] The heat of a human organism emits 75% through evaporation, 0-20% over physical work, 10% over convection, up to 5% through breathing, and up to 1% over conduction when the human organism is in warmer ambient surroundings.[77] In accordance to the different transport mechanisms of the heat dissipation the elements of climate (air temperature, wind velocity, short-wave and long-wave radiation and humidity) play a role in the exchange process of heat generation. The difference between the size on the skin surface and the size in the environment is decisive for the direction and magnitude of the heat flow.[73] [45] Therefore heat stress cannot be adequately described only by air temperature.[78]

Human thermal exchange with the environment is described as follwing:[79]

S – rate of heat storage = M ± W ± R ± C ± K − E − RES [W/m2]

M – rate of metabolic heat production

W – rate of mechanical work accomplished

R – rate of heat exchange by radiation

C – rate of heat exchange by convection

K – rate of heat exchange by conduction

E – rate of heat exchange by evaporation

RES – rate of heat exchange by respiration

The development of heat and the heat dissipation are controlled in the human organism by the thermoregulation system. The hypothalamus (part of the diencephalon) is the primary control center for the thermoregulation of the human organism and is responsible for the regulation of the complex process.[80] The thermoregulation mechanisms have a minimal activity under the condition of thermal comfort (37°C) and due to physical rest the energy consumption is low.[81] However, the thermal regulation is linked with blood pressure, in the event of increased stress caused by heat or cold stimuli , the demands placed on the cardiovascular system are also increased.[79] [76] The center of the thermoregulation receives signals transmitted by the thermoreceptors of the skin. Based on a complex evaluation, the heat regulation is controlled mainly by three mechanisms; the blood flow of the skin, the production of sweat and the cold chattering. These mechanisms run autonomously.[82] Besides the three mechanisms the human behaviour can also capriciously influence thermoregulations due to clothing or movement. At first, the heat is transferred to a small degree by conduction into the tissues and afterwards the most part of the heat is transferred by convection due to the blood stream to the skin.[83] During the evaporation process of the perspiration on the skin surface the heat evaporation is extracted from the skin. The skin and the flowing blood get cooled by the thermoregulation. Thus the blood can flow back into the core of the body and lower the temperature.[84] [82] Due to a warm environment the blood vessels of the skin supplying blood to the skin and can swell or dilate. This mechanism is called vasodilation. This causes more heat to be carried by the blood to the skin, where it can be lost to the air.[81] In cold environments the blood vessels can shrink down again - called vasoconstriction. This mechanism reduces heat loss through the skin if the body's temperature has returned to normal (37°C).[80] Vasodilation and vasoconstriction change the conditions of the blood pressure, the heart rate and the respiratory rate.[85] High air temperatures reduce the required temperature gradient and high humidity increases the problem because of the evaporation on the skin is controlled by the humidity gradient. If the evaporation of the moisture on the skin is diminished or is no longer possible the cooler of evaporation is missing. Therefore high air temperatures and high humidity are a burden for the human organism[86]. Healthy Humans have an extraordinary high level of adaptability due to different atmospheric conditions (acclimatization). Assuming that the human autonomous regulation provides this adjustment performance.[87]

Short-term heat acclimatization usually occurs after 3-12 days; however, long-term heat acclimatization could last several years.[87] Short-term heat acclimatization results in an increased sweat production even at low body temperature reduced salt concentration in sweat and urine, increased blood volume, a reduced body core temperature limit for vasodilatation, a reduction in metabolic rate and heart rate.[85] This type of acclimatization only occurs if heat exposure takes place daily over several hours, and when it recovers within several weeks after heat exposure.[78]

Long-term heat acclimatization results in an increased drain of heat via a flux of sensible heat to avoid ineffective loss of sweat.[88] The speed and intensity of acclimatization depend on different individual factors such as age, gender, genetic predisposition, health status, physical performance and fitness.[89] In addition, external factors, such as, the use of air conditioning systems, as well as national, geographical and seasonal differences are involved in the degree for acclimatization and individual heat tolerance.[90] In 2005 Koppe developed the method HeRATE (Health Related Assessment of the Thermal Environment). Due to this procedure it is possible to evaluate the physiological adaptation of the thermal environment. This developed for the calculation of the threshold values of the thermal sensation for the heat warnings of the German weather service (DWD).[84] It is well known that heat waves have stronger health impact in spring or early summer due to an insufficient acclimatization of the organism.[6 91 74] In addition, the health effect of heat stress is dependent on its intensity and duration of the exposure.[74]

The human organism tolerates deviations of the core body temperature only to a very small extent. Beyond a healthy range is defined as a deviation of ± 3.5°C from the resting temperature of 37°C. According to Moran (2002) this deviations of the core body temperature above the limited value can result in physiological impairments and fatality.[75] On the other hand the periphery parts of the body are less sensitive against varying temperatures. If the core temperature rises or if the upper limit of the human thermal comfort zone (37°C ± 3.5°C) are reached the organism is increasingly stressed by heat stress.[79] Even healthy humans who are exposed to heat can suffer from this exposure. We can observe a considerable increase of the pumping capability of the heart.[71] This could lead to a reduction of the resources of physiological functions and reduce intellectual cognitive work.[92] The response of the human body will be; a discomfort feeling, a diminishing of the physical performance, and a lower ability to concentrate.[65] If the exposure to high temperatures is persistent, this can lead to heat-related diseases. Proteins can be damaged, if the body core temperature increase above 41°C (hyperthermia). This will lead to inadequate vasoconstriction and a stop in sweat production and a further increased heat production due to trembling. High temperatures also change the haemostasis and the viscosity of the blood as well as the number of red blood cells.[93] Therefore heat stress can act as a trigger for cardiovascular (heart and vascular system) and cerebrovascular (brain and blood vessel related) disease,[94] as well as for respiratory system diseases.[95] The impacts of health effects from air pollution and pollen also influenced by heat.[19] [96] High temperatures and a low humidity can dehydrate the membrane mucous of the oral cavity and the nose. Due to a dry mucous membrane harmful pathogens can easily develop.[97] This can lead to various infectious diseases (e.g. endocarditis, pulmonary infection etc.).[98] [99] An ambient high temperature also results in a loss of water though the surface of the skin. Additional health circumstances like diabetes mellitus or diarrhea reinforce the dehydration of the human organism.[100] A high loss of water is particularly problematic for elderly and sick people, infants and toddlers. [101] [102] This target group has a limited capacity to adapt the thermoregulation system due to the environment.[103] Furthermore the perception from elderly people to drink diminishes and hormonal regulations for water and electrolyte balance change.[104] If the water and electrolyte balance of a human body is not adequately compensated this circumstance can lead to a loss of volume in the circulatory system. Due to an impairment of circulatory function and reduction of the renal activity there is a high risk for a collapse of the human organism.[105] In a short time perspective young adults have the capacity to compensate this dehydration circumstance of the situation. However, elderly individuals often require several days to compensate dehydration thus they are at higher risk to get cardiac and cerebral damages.[105] Humans that already suffer from cardiovascular-, respiratory diseases, people who are confined to bed, people with neurological and/or psychiatric disorders are also vulnerable to heat exposure.[74 15 3 106] Due to the general underlying disease this target group usually relies to take medication like diuretics, neuroleptics, beta blocker and barbiturates which could have a negative health impact on the fluid and electrolyte balance of vulnerable humans. Social isolation and little mobility were identified as key risk factors during heatwaves.[107 92 108] Other contextual risk factors include no access to an air-conditioned environment, living in homes with high thermal mass and little ventilation, and living on the upper floors of high rise buildings.[108 9 39 109] Elderly people in hospital and residential homes are also at increased risk because of their physical frailty and therefore need particular attention from HCP.[8 110 111] People that living in cities are more vulnerable than those living in rural areas. Partly because of the urban heat-island e□ect, whereby city temperatures are raised as a result of increased thermal storage capacity.[112] According to the Robert Koch Institute the following conditions are also related to heat health risks: Addiction to drugs and alcohol, strenuous physical activities during extreme weather conditions, lack of acclimatization, low levels of fitness, obesity, physical exhaustion and a low level of socio economic status.[34]

According to the latest published recommendations of the WHO in 2011 heat related health conditions can be determined in mild and moderate heat illnesses and life-threatening heatstroke. The following table 1 shows the various medical conditions their symptoms and how to manage the heat related disease.[113]

Table 1: Medical conditions due to heat-related effects on the human organism, the signs and symptoms and how to manage the health related risks.

Medical condition	Signs and symptoms/ mechanisms	Management
Heat rash	Small red itchy papules appear on the face, neck, upper chest, under breast, groin and scrotum areas. This can affect any age but is prevalent in young children. Infection with Staphylococcus can occur. It is attributed to heavy sweating during hot and humid weather.	Rash subsides with no specific treatment. Minimize sweating by staying in an air-conditioned environment, taking frequent showers and wearing light clothes. Keep the affected area dry. Topical antihistamine and antiseptic preparations can be used to reduce discomfort and prevent secondary infection.
Heat oedema	Oedema of the lower limbs, usually ankles, appears at the start of the hot season. This is attributed to heat-induced peripheral vasodilatation and retention of water and salt.	Treatment is not required as oedema usually subsides following acclimatization. Diuretics are not advised.
Heat syncope	This involves brief loss of consciousness or orthostatic dizziness. It is common in patients with cardiovascular diseases or taking diuretics, before acclimatization takes place. It is attributed to dehydration, peripheral vasodilatation and decreased venous return resulting in reduced cardiac output.	The patient should rest in a cool place and be placed in a supine position with legs and hips elevated to increase venous return. Other serious causes of syncope need to be ruled out.
Heat cramps	Painful muscular spasms occur, most often in the legs, arms or abdomen, usually at the end of sustained exercise. This can be attributed to dehydration, loss of electrolytes through heavy sweating and muscle fatigue.	Immediate rest in a cool place is advised. Stretch muscles and massage gently. Oral rehydration may be needed, using a solution containing electrolytes. Medical attention should be sought if heat cramps are sustained for more than one hour.
Heat exhaustion	akness, discomfort, anxiety, dizziness, fainting and normal, subnormal or slightly elevated (less than hypotension and rapid shallow breathing. There is an be attributed to water and/or salt depletion ronmental heat or strenuous physical exercise.	Move the patient to a cool shaded room or air conditioned place. The patient should be undressed. Apply cold wet sheet or spray cold water and use fan if available. Lay the patient down and raise his or her legs and hips to increase venous return. Start oral hydration. If nausea prevents oral intake of fluids, consider intravenous hydration. If hyperthermia above 39 °C or impaired mental status or sustained hypotension occurs, treat as heatstroke and transfer the patient to hospital.
Heat stroke	Diagnosis of heatstroke should be suspected in any patient with changes in mental status during heat stress even if the temperature is < 40 °C. Symptoms include hyperpyrexia (temperature above 40,5 °C), Hyperventilation (high frequency breath), central venous disorder, pulmonary oedema, insufficient function of the renal system and shook.	Promote cooling by conduction; maintain currents of air. Promote cooling by evaporation. Minimize risk of aspiration. Increase arterial oxygen saturation to > 90%. Ensure volume expansion. Monitoring at the intensive care unit.

Medical condition	Signs and symptoms/ mechanisms	Management
Hyperthermia	Confirm diagnosis with thermometer calibrated to measure high temperatures (40–47 °C). Multiple organ damage	Keep skin temperature > 30 °C. Stop cooling when rectal temperature is < 39.4 °C. Monitoring at the intensive care unit. Control seizures. Protect airway and augment oxygenation (arterial oxygen saturation to > 90%). Increase mean arterial pressure > 60 mmHg, restore organ perfusion and tissue oxygenation (consciousness, urinary output, lactate level).Prevent myoglobin-induced renal injury. Promote renal blood flow and diuresis. Ensure urine alkalization. Prevent life-threatening cardiac arrhythmia. Aid recovery of organ function.

Adapted from the WHO heat-health action plan (2008).[113]

In Germany the lowest mortality rate is observed if the mean daily air temperature is between 19°C and 22°C.[114] During heat waves the excess mortality rate (an increased mortality rate of heat vulnerable group compared to the population average) can also exceed in winter maxima.[115] This is exactly what happened in the winter 2004 in Berlin (see figure 6).

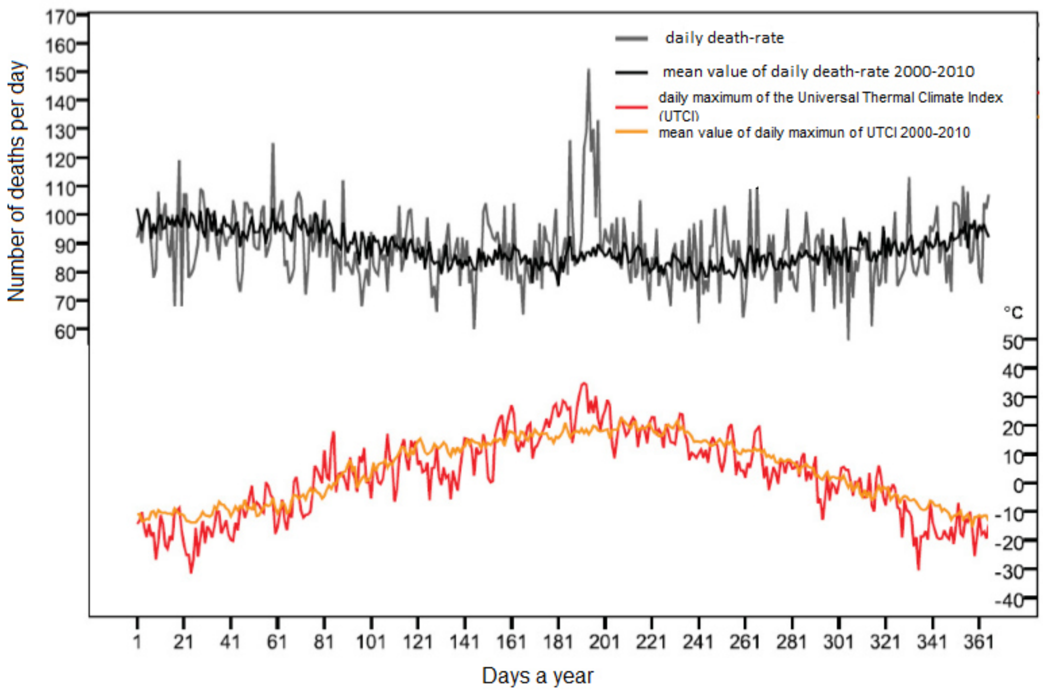

Figure 6: Daily mortality-rate (all causes) and the daily maximum of the UTCI in Berlin in comparison with the mean value of the basis 2000 – 2010. Adapted from AfS Berlin-Brandenburg, DWD, Scherber (2013).[1]

Seasonal differences in the vitality of the human immune system, the seasonal living conditions and the seasonal occurrence of pathogens (e.g. influenza in the winter) are the causes of the seasonal fluctuations. Generally from early summer till the middle of autumn the human organism achieve a relatively adequate immune defense. The premature death of patients that already seriously ill and have a high risk of death.[10]

The “Harvesting effect” in scientific research about heat- related mortality is very well discussed.[116] [117] This effect describes the process of a premature death in patients/residents who are already seriously ill and have a high risk to die .[118] After an increased morality rate induced by heat, we can observe a low rate of morality. Rocklov and colleges pointed out that the size of the harvesting effect can be estimated.[119] The calculation depends on various effects, for instance: the demographic, social and regional factors as well as the general health status of the population, methodological approaches and the previous winter mortality.[34] The harvesting effect can only explain a small amount of the observed mortality increase. So far the effects of thermal stress on human health had been mainly investigated by the mean of mortality data.[120] The numbers of deaths could be just the tip of the ice-berg, if we want to draw conclusions about the entire population. Within this assumption it must be assumed that healthy people are also impaired in performance and well-being due to extreme environmental conditions. Furthermore people who are already disabled by disease-related capacity to adaptation against environmental extremes react with a reduction of the general health status.[121]

2.4.1 Relevant Trials on heat-related Health and Care

- International Trials

Actually, on the international level, published trials about the degree of heat risk awareness and the adaptation measures applied in hospitals and retirement homes are not abundant in the scientific literature. Only few trials cover this domain. The scientific survey of Ibrahim and colleges (2011) estimated the awareness, knowledge, and practices of health professionals and care providers due to minimizing harm from heatwaves in Victoria, Australia. Besides a broad level of understanding of the dangers of heatwaves the researchers discovered that an opportunistic, reactive approach by health profession and care personnel, in conjunction with gaps in knowledge, leaves older people in Victoria at risk of preventable harm from extreme hot weather.[122]

Sheffield and colleges (2014) conducted a qualitative study to determine the emerging roles of HCP due to mitigation of climate change impacts in East Harlem, New York. The researchers showed that HCP demonstrated their interest in playing a role in climate change adaptation by identifying at-risk patients and helping to tailor clinical care to better serve these individuals.[123] In 2013 the Australian National Climate Change Adaptation Research Facility had published a research report on the heatwave awareness, preparedness and adaptive capacity in aged care facilities in three Australian states. They estimated that 90% of the facilities had a current aged care facility emergency plan, although only 30% included heat-wave emergency planning (n= 287≙18%). Heatwave policies were not routine in all aged care facilities in any state. Staff used a range of strategies to keep residents cool in extreme heat (e.g. messages; cooling, hydration, monitoring and emergency planning), although strategies were not consistent across all states or facilities.[16] In the context of the European project PHEWE (Assessment and prevention of acute health effects of weather conditions in Europe) researcher determined a positive association between the increase of high temperatures and risk of hospitalization for respiratory diseases, with geographical heterogeneity.[74] [124] In a multi-city case-crossover analysis Stafoggia and colleges did research on in-hospital heat-related mortality at four cities in Italy. They estimated that age, marital status and hospital ward were important risk indicators for heat related mortality. Furthermore the investigated that patients in general medicine are at higher risk than those in high and intensive care units.[125]

A resent meta-analysis supports existing evidence that heat warnings systems reducing heat-related mortality and potentially morbidity. We can expect if stationary HCP receive heat warnings, they are in the position to implement heat intervention actions.[126] The knowledge of an upcoming heat wave therefore can be structured and guidelines could be developed to instruct the heath care staff. Also Ebi and Colleges determine that there is indirect evidence that heat-health warning systems which couple early warnings with a broad array of emergency response measures save lives, though it is unknown which of the measures contribute to any reduction.[26]

- National Trials

Direct proper scientific literature about the degree of heat risk awareness and the adaptation measures applied in hospitals and retirement homes in Germany could not be found on the national level. Furthermore, there is no scientific evidence how HCP act in the case of an increased temperature rise due to heat measures (e.g. heat waves).

So far, national studies and publications estimate the health impacts of heat events in Germany on a general public health level and discuss the adaptation strategies for urban environments.[59 25 127 128 129] In a qualitative study of 24 German cities Donner and colleges reported a significant and realized need to implement health management strategies for urban areas that have to deal with heat related health risks. Only the half of these cities addressed heat stress specifically in their health management plans.[59] Furthermore, heat alert systems were only found in nine of the plans. In 2013 Capellaro and colleges evaluated the information and early warning systems by means of polls of the population, the authorities and the environment and public health agencies in Germany due to heat. The evaluation estimated that HCP have serious concerns about extreme weather events, but on the other hand the facilities do not have a sufficient number of proceedings against heat that have an impact on patients/residents.[130]

In Baden-Würthemberg there is evidence about the significant association between high temperatures and an increase in the general mortality rate identified by a 30 year time series studies.[131] Due to the European research project "EuroHEAT" one observed an increase in mortality for Munich during heat waves by 7.6%.[127] Furthermore, investigations of high temperatures on morbidity show various results. On the one hand, investigations were able to demonstrate an increase of rescue missions and emergencies admissions induced by extreme heat.[10] On the other hand, one could not find statistical evidence about increased rescue missions. Heart problems occur mainly during high and extreme temperature conditions.[3] Further results of the EuroHEAT study showed that high air temperatures can be more pronounced in myocardial re-infarctions than in the case of primary infarctions due to chronic coronary heart diseases that can develop after primary infarction of the heart.[132] However, further investigations showed differences between cardiovascular and respiratory disease due to morbidity effects. For instance, one single study estimate an 1% increase of daily COPD ambulant patient consultations in Bavaria due to a change in temperatures of 0,72 K. [74 133]

- Regional Trials (Berlin)

Few trials and published scientific literature that take into account the degree of heat risk awareness and the adaptation measures applied in hospitals and retirement homes are available for Berlin. Indeed, various studies did investigations on the health impacts of thermal burden and air pollution for the citizens of Berlin.[134] [115] [40] For the region of Berlin new epidemiological studies that measure the effects of heat stress have been reported by Gabriel (2011), Burkart et al. (2013), Scherber et al. (2013) and the RKI within the framework of the European Mortality Monitoring Project (EuroMoMo).[135]

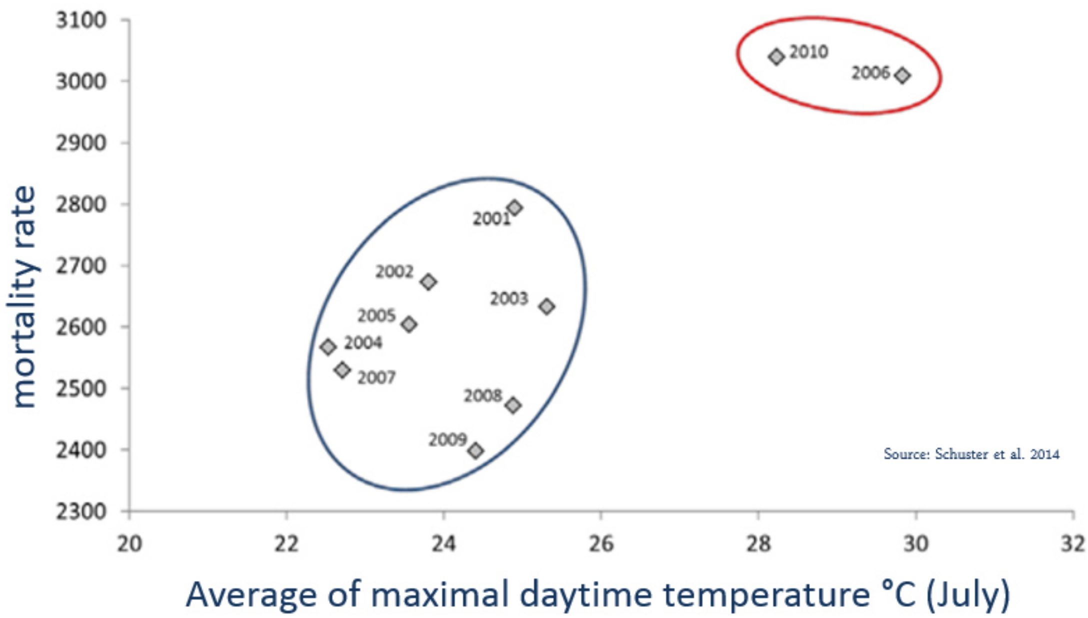

Figure 7 Relation between maximal daytime temperature (July) and sum of the mortality rate from 2001-2010. Adapted from Gabriel and Colleges (2014).[10]

The urgent need of research on the effects of heat stress on the health status of the citizens in the Berlin region, specifically on climate change and urban climate is supported by the research projects "INKA BB - Innovationsnetzwerk Klimaanpasung Brandenburg Berlin"[136] and "UCaHS - Urban Klima und Hitze Stress in medium-sized cities with regard to climate change.[137] Schubert and colleges (2016) showed the curative effect of convection free climatized rooms onto early mobilization in hospitalized patients, diagnosed heat stress induced acute exacerbation of chronic lung disease by means of tracking physical activity. In this randomized trial the patient in climatized rooms had a 25,6 % higher mean daily activity count rate compared to the control group.[138]

For a brief and structured overview of the state of the art in Berlin the following table will present the scientific research, the used methods and the findings that take into account heat-related health risks.

Table 2: Comprehensive summery of the state of the art heat-health related research for Berlin from 1987 till present.

Authors and Title	Duration	Variables	Description	Findings
Schubert et al. 2016: Novel climatization enhances early mobilization in patients hospital admitted due heat stress induced acute exacerbation of lung disease chronic [138]	2014-2015	32 COPD patients, physical activity, stay in hospital.	Randomized Clinical Trial; 32 patient COPD 1) air-conditioned rooms and 2) non air-conditioned rooms in hospital. Investigation of early mobilization, period of hospitalization.	Patients in climatized rooms (G1) had a 25,6 % higher mean daily activity count rate at 399 Moves (KI 95%, 214-584, p< 0.05) compared to control group (G2) at 301 Moves (KI 95%, 188-414, p< 0.05).
Burkart et al. 2013: Interactive short-term effects of equivalent temperature and air pollution on human mortality in Berlin and Lisbon.[139]	1998-2010	Numbers of death, all causes; Universal Thermal Climate Index (UTCI), based on the meteorological parameter PM10, ozone	Investigation of heat and Cold air load impacts Measurement of mortality risk	The risk of mortality is associated with an increase with heat stress. High concentrations of ozone and PM10 are associated with increased heat-related mortality
Fenner et al. 2015: Inner city air temperature as indicator of health problems in major cities : an example of Berlin.[53]	2001-2010	Numbers of death, all causes; Age groups (all, 0-64, 65+) Air-temperature	Investigation of thermal effects under the dependency of inner city climate conditions; Quantification of the Exzess Mortality based on the heat stress risk model by Scherer et al. 2013	Strong connection between tropical nights and increased mortality. However, even during cooler nights a statistically significant increase in mortality can be detected. Overall, approximately 4–5 per cent of all deaths in Berlin can statistically be linked to heat events

Authors and Title	Duration	Variables	Description	Findings
Gabriel und Endlicher 2011: Urban and rural mortality rates during heat waves in Berlin and Brandenburg.[10]	1990-2006	Numbers of death, all causes; Age groups (< 50, > 50); gender; Meteorological parameters, felled temperatures land cover, degree of sealing	Epidemiological study; Investigation of thermal effects- Measurement of excess mortality	In Berlin and Brandenburg mainly elderly (> 50-year-olds) and especially women have increased heat vulgarity. The mortality rate increases with the density of urban structures.
Jehn et al. 2013: Telemonitoring reduces exacerbation of COPD in the context of climate change--a randomized controlled trial.	1.Juni-31.August 2012	measuring pulmonary function, clinical status (CAT- Test for COPD patients), 6-min walk- test Days of heat stress on based on air temperature	Clinical trial with 62 COPD-patients (chronic obstructive pulmonary disease); Investigation of heat effects; telemedicine based study	Heat stress increase physical impairments of COPD patients. Telemedicine care helps to reduce the frequencies of the physical impairment (exacerbations)
Jehn et al. 2014: Heat Stress is Associated with Reduced Health Status in Pulmonary Arterial Hypertension: A Prospective Study Cohort.[140]	1.April-30.Septembe r 2011	Steps, symptome score, Days of heat stress on based on air temperature, humidity	Prospective cohort study with 15 PAH-patients (respiratory-arteria hypertonia); Investigation of heat effects by activity and symptom monitoring.	Heat stress is associated with a compromised clinical status in patients with PAH.
Langner et al. 2014:. Indoor heat stress: An assessment of human bioclimate using the UTCI in different buildings in Berlin[45]	1994-2010	Universal Thermal Climate Index (UTCI), 16 Rooms in Berlin	Investigation of Heat and Air pollution effects; spatial analysis; projection about heat related morbidity and mortality.	The UTCI values were used to determine the occurrence of moderate and strong heat stress. Only two rooms showed no thermal stress, while strong heat stress was detected in three rooms.
Scherber et al. 2014: Spatial analysis of hospital admissions for respiratory diseases during summer months in Berlin taking bioclimatic and socio-economic aspects into account.[131]	2000-2009	Hospital admission; arteria coronary disease age groups 65+ social index mean of the year, heat load days	Spatial analysis of hospital admission risk for patients with arteria coronary disease in consideration SES factors an heat stress.	significantly positive relationships between relative risks for hospital admissions among > 64-year-olds with RD and population density, socio-economic conditions and the annual mean number of days with heat loads on the basis of the period 1971–2000 and the average of the periods 1971–2000 and 2021–2050 at the zip code level in Berlin

Authors and Title	Duration	Variables	Description	Findings
Scherer et al. 2013: Quantification of heat-stress related mortality hazard, vulnerability and risk in Berlin.[47]	2001-2010	Numbers of death; all cases ; Age groups (all, 0 – 64, 65+) Air temperatures	Investigation of heat effects; Quantification of Excess mortality based on a heat effect risk model	The study reveals that about 5 % of all deaths between 2001 and 2010 in Berlin can statistically be related to elevated air temperatures
Schuster et al. 2014: Heat mortality in Berlin – Spatial variability at the neighbourhood scale.[44]	2006-2010	Numbers of death; all cases Air temperature; German weather service- heat warnings	Inner city spatial analysis Analyse about heat related excess mortality	Intra-urban patterns of heat-related excess mortality revealed substantial spatial variability. Temporal aggregation of mortality data enabled neighborhood-scale spatial resolution.
Turowski und Haase 1987: Meteoropathologische Untersuchung über die Klima- und Wetterabhängigkeit der Sterblichkeit.[141]	1958-1967	Numbers of death; all cases , age groups, gender meteorological parameter	Investigation of weather associations : Calculation on increased mortality	An increased mortality in summer correlates significantly with increased air temperatures, increased humidity and increased global radiation

2.4.2 Heat and Health Care- International Perspective

In a recent review of 23 international selected heat wave response plans with a particular focus on specific responses aimed at residents of retirement home facilities one have had identified that only three heat wave plans included specific guidance for retirement home facilities.[142] These three are: the Canadian technical guide for healthcare workers (Health Canada, 2011), the English national plan (UK Department of Health, 2010), and Residential Aged Care Services Heatwave Ready Resource for Victoria, Australia (Victorian Government Department of Health and Human Services, 2010). The action plan of Canada highlighted in particular disaster preparedness for nursing homes without air-conditioning. Furthermore, Toronto as a city provides six relief short term stay beds for use by frail isolated people during an extreme heat alert. The English national plan underline the importance of observation due to the risk of dehydration in elderly people that living in retirement homes. The Australian action plan of Victoria includes for instance measurements such as, a checklist on heat wave planning in retirement homes, as well as heat wave information to assist the development of brochures, flyers, or posters.[142]

The occurrence of the European heatwave in 2003 led to a fundamental rethink of quality standards at retirement homes in some European countries, such as, UK, France and Italy. The French government established regulations, that retirement homes should have had at least one cool room at their institution were elderly people can rest.[143] However, a report that focused on the response of heat wave action plans in 12 European countries (Germany also included) showed that just a few of these countries implement preventive actions or advices particular for health care institutions.[144] The French action plan provides multiple information brochures for health professionals of adults (through nursing homes and leaflets targeting health professionals) to generalize heat health individual behavioral advice.[143] Due to the findings in the literature of scientific work one can assume a significant shortcoming of health care institutions that must be addressed in future heat wave response planning.

2.4.3 Heat and Health Care -National perspective

In general, an effective prevention and an adequate procedure to reduce heat-related health impacts in aged care facilities are rather poor due to their contextual framework in Germany. In the followed section the areas of weaknesses for HCP will be described:

Organization

- The supervisory authorities of aged care facilities in Germany are; the Medical Review Board of the Statutory Health Insurance Funds (MDK), Federal Joint Committee (GABA) and the home supervisory authorities (Heimaufsicht) for each local district in Germany. In any of the inspection catalogues or directives of the mentioned supervisory authorities one cannot find a particular measure or procedure that have to be implanted in health care settings that take into account heat related health risks for patients/residents. [145]

Building and Equipment

- Guidelines of the minimum residential home standards in Germany do not provide technical and nonstructural heat prevention measures.[146]

Development of Care standards

- The development of a care planning instrument is carried out in agreement with the expert standards of the “German Network for Quality Development in Care's (DNQP)”. Within these expert standards heat-related health effects are hardly taken into account. A powerful framework due to a DNQP expert's standard for the maintenance of heat related illness is not available.

- The German Health Insurance Medical Service (MDK) does not implement an assessment tool to monitor HCP due to heat-related health problems.[147]

Medicine

- Retirement homes in Germany do not belong to medical facilities. Therefore, the medical care of residents take place by general practitioners. Thus, a medical contact on side is missing to detect heat related illness, such as, dehydration and prompt implementations for necessary measures for heat adaptation can be difficult to arrange.[148]

3 Methods

The conduction of the data is developed within three overall steps; the systematic literature research, the semi-structured expert interviews and the heat awareness and adaptation questionnaire. The development of this multi method approach will be described in the following chapter.

3.1 Systematic Literature Research

An extensive review about the issue “heat awareness and adaptation of HCP” were performed. Several databases were searched, including CINAHL, PubMed, Science direct/ Elsevier, Springer eBooks-Biomedical and Life Sciences and Sage that focusing on awareness and adaptation of HCP due to the impact of heat related health risks for patients/residents placed in healthcare settings. We focused on two specific objectives. One the one hand we wanted to get an overview about the research issue and on the other hand the extended literature research supported the evidence for development of a semi-structured interview guideline for the expert interviews.

We used the searching terms as followed: “((((health care providers’ AND heat adaptation), (environmental health AND heat), ((heat action plan), heat AND hospitals), (heat AND hospitals OR retirement AND homes), (heat awareness AND heat behaviours))))”.

In this literature research full text articles, reviews and/or meta-analysis, langue: English and German are taking into account. The search criteria include literature that focus on the issues that take into account: adaptation and awareness of HCP related to heat-vulnerability and health risks for patients and residents that stay/live in hospitals/retirement homes.

The investigation revealed 12 quantitative and 2 qualitative records. For a systematic research procedure the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) process were applied:[149]

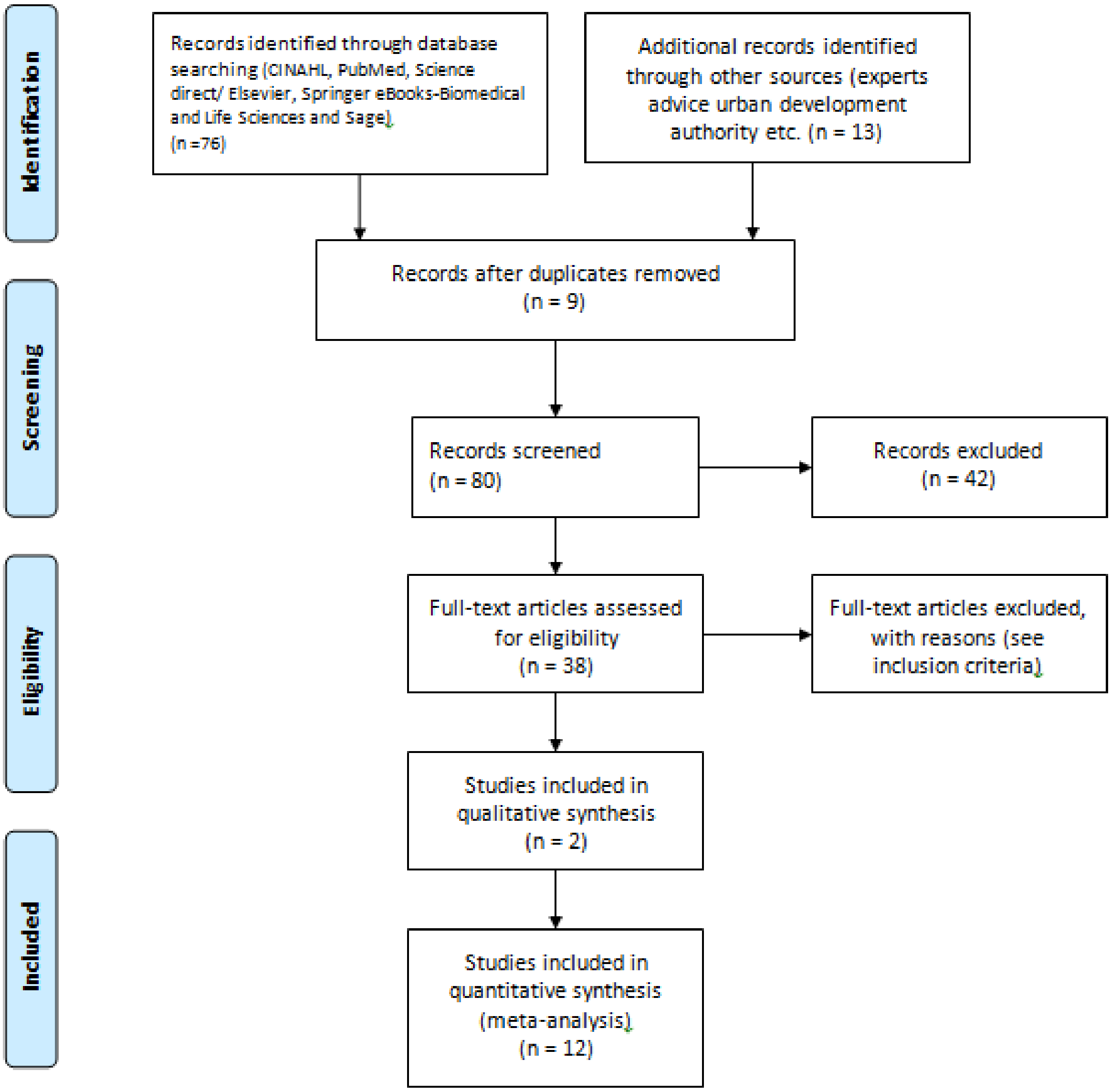

Figure 8: Flow chart of the systematic Literature research conducted according to the guidelines of the PRISMA approach.

Due to the information of the literature research it was possible to:

- Verify the target group
- Generate a categorical-cluster for the comparability of the results
- Develop a semi- structured guideline-interview
- Develop a first draft stationary healthcare provider survey regarding heat risks.

3.2 Recruitment of Participants for the Qualitative Part

The qualitative part of the study is based on a semi-structured expert interview guideline (see Appendix 9.1). The objective of this method is to generate expert knowledge of the current procedures, challenges and perspectives in this field of research. Furthermore the information will help to develop the quantitative questionnaire for HCP and provide recommendations for innovative strategies that may can be implemented in stationary health institutions to increase the awareness and adaptation of heat related health risks.

Three participants of the interviews were experts from the research project "Urban Climate and Heat Stress in mid-latitude cities in view of climate change (UCaHS)". This expert group involves climatologists, urban geographers and hydrologists, physicians, architects, physicists and engineers, urban planners and social scientists. All of them are involved in various studies that are related to the research subject heat and human health in Berlin. Further experts were recruited through professional contacts, from identification of contributing authors in the literature, and from snowball recruitment by which one expert suggested others. The subject of the research is on a multidimensional level. Political decisions have a massive influence on behaviour of stationary HCP due to heat adaptation. Therefore participants of the local authorities "Senatsverwaltung für Gesundheit, Pflege und Gleichstellung" and the „Senatsverwaltung für Umwelt, Verkehr und Klimaschutz" are also involved as experts in the semi-structured interviews. In the end 13 experts could be recruited for the interviews.

3.3 Recruitment of Participants for the Quantitative Part

In a second step this study runs a quantitative survey of heat awareness and adaptation of stationary HCP. Retirement home facilities across Berlin were identified using a dataset of the Department of Health in Berlin (Senatsverwaltung für Gesundheit und Soziales, Abteilung Gesundheit, I D 1) and via internet searching. The identification of hospitals was generated by the dataset of the Berlin hospital register (Berliner Krankenhausverzeichnis GmbH). The information of both Data sets include the name, address, amount of patient beds and the medical or care discipline the intuitions offer.

The target settings of participation in the questionnaire are stationary health care intuitions in Berlin. In this case stationary HCP are defined as hospitals and retirement homes that are located in Berlin. Another inclusion Criteria of participation was the numbers of beds. Stationary HCP with less than 50 patient beds are excluded, because of insufficient access of the main target group.

With regard to the references of the expert interviews we defined the management / quality management of stationary HCP as target group to participate in the survey. The management and quality management of a HCP can give the best response regarding the standards and regulations (e.g. heat intervention standard operating procedures) due to heat risk preventions of an institution. This target group is also involved in the development of building and equipment structure of HCP which has an important role in heat intervention actions, such as, implementation of air-conditioning, heat-isolation of the building. To generate direct contacts with the managers of the stationary HCP an internet investigation was necessary. HCP that do not have a direct contact of their institution manger on the webpage were excluded from the study. Furthermore HCP that are specified on the secondary health care market (e.g. wellness, nutrition) are also excluded from this study. The vulnerability to heat for patients or rather clients seems to be less and is not focused in this research. Each stationary HCP was contacted by e-mail and invited to participate in the survey. Within six weeks three reminders were sent via e-mail to the stationary HCP that did not participate yet. After this procedure follow up telephone calls were made to all facilities to motivate them to participate in this study. To optimize the questionnaire we run a pilot study in Hamburg in 40 hospitals (n=8 response rate).

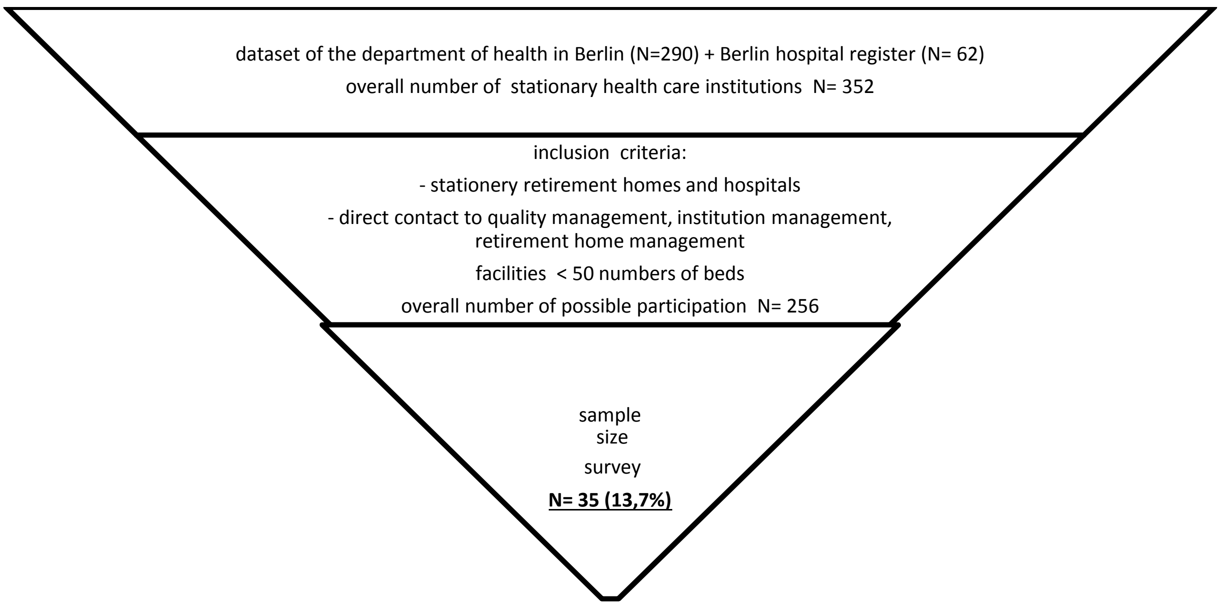

Figure 9: Procedure of the participant recruitment for the heat awareness and adaptation survey of the stationary HCP.

3.4 Statistical Analysis of the Survey

Statistical analyses were performed using SPSS for Windows version 22. A two-tailed threshold of 0.05 was chosen to indicate statistical significance. Variables are presented as mean (±standard deviation [SD]) for continuous variables and numbers (percentage) for discrete variables. For the analysis, we assumed that data were missing at random. All baseline characteristics were presented in descriptive frequencies. To understand the associations between heat risk awareness and heat risk adaptation of HCP (H1) linear regression analysis were used because of scaled data set.[150] Spearman rank correlation were used to estimate associations between increase in patient care during hot days (30°C) and an increased need to recruit health care staff during those days (H2) because of ordinal data.[151] To verify the quality of the items within the questionnaire we performed the measurement of internal consistency (plausibility). Therefore we used the Cronbach's alpha test. Cronbach’s alpha is the most common measure of scale reliability.[152]

3.5 Development of the Heat Risk Awareness and Heat Adaptation Survey

We develop a questionnaire to measure the awareness and the adaptation of stationary HCP due to current procedures, strategies, knowledge and environmental factors, such as, building design and cooling equipment that were used at their institutions, which maybe prevent heat associated morbidity and mortality of patients/residents. Based on an extended literature research we developed a draft questionnaire with 37 items.

An important aspect to face empirical evidence we conducted 13 interviews with experts to evaluate the draft questionnaire. The main target for the experts’ was to review the draft questionnaire and to give recommendations to heat adaptation strategies. We used a ‘think aloud’ technique for the interviews. In a thinking aloud technique, the experts were asked to get through the draft questionnaire while continuously thinking out loud - that was, simply verbalizing their thoughts and wrote recommendations of the items as they moved through the user interface of the questionnaire.[23]

Interviews were audio-recorded, transcribed and analysed thematically. Methodically the “think aloud” approach as a qualitative data collection method has been widely used in cognitive psychology as a means of collecting verbalizations about productive thinking and a way to understand individual development of thought. Think aloud approaches have been extensively used in educational contexts. [153] [154] [154] Data collection focuses on the following three assumptions; firstly that human cognition is an information processing process, secondly cognitive processes can be acknowledged through discourse and thirdly that thinking aloud provides an indication of current and concentrated information.[155] Due to this approach the heat risk awareness-index and the heat adaptation-index were developed by the estimation of the experts' recommendations and the scientific evidence of measurement out of the literature research.

3.5.1 Components of the Survey

- Sample characteristics

A query of institutional (two items e.g. number of beds) and individual (4 items e.g. profession of the responder) information was implanted into the survey to generate a convincing value of the data.

- Awareness of heat risks

About seven Items were identified that create a general overview about the heat risk awareness of HCP (e.g. the interest of heat adaptation strategies).

- Information & communication in terms of heat

Information of and about high temperatures early on produced a broad sensitization and acceptance. To receive information and also to spread the information is important to take heat action adaptation. Four items were identified to generate knowledge about the level of information and communication of heat related hazard.

- Administration & competences in terms of heat

The responsibility of a specific task determines the appropriate response and advice to those who need to be aware of the situation. Therefore this flied of research identified responsible target groups for heat adaptation in the health care institutions (two items).

- Modalities of heat interventions

In order to get a deep insight of the interventional strategies of the HCP against high temperatures 10 items has been specified such as, procedures of fluid intake, balancing of fluid intake. The query of each item has been specified on the degree of implementation due to heat interventions at the health care institution. Insofar as it can be assumed that the degree of implementation due to heat measures is higher if the health care institution conducted heat interventions via standard operating procedures (SOP) the classification of the interventions are divided into “qualified personnel take action regard to SOP`s” or “qualified personnel take action regard to individual decision”.

- Analysis of building structure & equipment

The surrounding of the HCP plays an important role due to the capacity to cope with high temperatures. Recent studies have identified air conditioning and modern housing as effective strategies for reduction of heat stress.[156] [157] This section of the survey estimate 12 items such as, air-conditioning, reflective roof, garden, south alignment that may mitigate high temperatures at indoor environment.

3.5.2 Index Development

Although individual questions from the questionnaire reliably measure specific aspects of the respondents’ for heat risk awareness and heat adaptation, a single measure (index) that summarizes this awareness and adaptation is useful both in identifying the determinants of such perceptions and in reporting study results to a broad audience. The goal of creating such an index was to reliably report a valid measure of heat risk awareness and heat adaptation in a simple, easy to understand manner. The further chapter will describe the development of the heat risk- and the heat adaptation index.

3.5.2.1 Heat Risk Awareness Index

In order to categorize the HCP who are (or are not) aware of heat related health risks we decided to define eight items that represent the level of heat realth health risk awareness. The justification of the selected items was done due to expert recommendations generated by the expert interviews and by evidence based literature.

The heat awareness index consists of eight questions which cover the domains of: knowledge to heat impact, interest of heat adaptation, received heat warnings, reasonability for heat adaptation, heat action plan, heat risk education and care of heat for health care staff. For each index items, there is a set of dichotomous question with a simple answer: “yes” or “no”. If any applicable question could not be answered with “yes”, than the responder do not score a point. Controversy if one question of the index could be answered with “yes” than the responder score one point. The response categories were counted in ascending order from 0 to 8. By counting the value of the answers one can come to a minimum score of 0 up to maximum score of 8 for each responder. Responders with a value of 0 to 1 were classified as “not tolerable”-, with a value of 2 to 3 as “tolerable minimum”-, with a value of 4 to 5 as “acceptable”-, with a value of 6 to 7 as “appropriate”- and responders with a score of 8 as “excellent” aware of heat risks. Each item is treated equally in the calculation of the awareness index. Based on the literature research we cannot determine any difference of effect size on improvement between evidence measures that increase the awareness of care providers due to heat.

3.5.2.1.1 Reliability of Heat Awareness Index

While there are many ways to define an index we decided to use statistical reliability analysis. Thus this procedure we wanted to determine if the scale was reliable. Therefore we used the methodical approach of Cronbach's alpha. Cronbach's alpha is defined as “a measure of internal consistency, that is, how closely related a set of items are as a group. It is considered to be a measure of scale reliability”.[158] A "high" value for alpha does not imply that the measure is unidimensional. For this approach we take into account that a reliability coefficient of .70 or higher is considered „acceptable" in most social science research situations.[152]

3.5.2.1.2 Results of the Awareness Reliability Test

For the analysis of the reliability of the heat risk awareness index we include the 8 loaded items in the test.

Table 3 Results of Reliability test for the development of the heat risk awareness index

Item Name	Corrected Item Correlated Total	Cronbach`s Alpha if Item delated
Knowlege_of_Heatimpact_Index	.491	.367
Discussion_about_Heat_Index	.315	.450
Interest_of_Heatadaptation_Index	.139	.505
Receipt_of_Heatwarnings_Index	.037	.553
Professional_for_Heat_Index	.213	.475
Heat_Action_Plan_Index	.343	.418
Education_about_Heat_Index	.232	.470
Heatcare_of_Medical_Staff_Index	.178	.489

The reliability test calculated with n= 29 (82.9%) presented a relatively low overall reliability coefficient of 0.528. The corrected items correlation ranged between 0.37 and 0.419 and if we deletes one particular item from the scale the value that Cronbach's Alpha would have ranged from 0.367 to 0.553. Due to this procedure we could not get a relevant increase of Cronbach’s Alpha if one execute a particular item (e.g. Receipt_of_Heatwarnings_Index= 0.553). According to the guidelines of Blanz (2015) the interpretation of Cronbach`s Alpha test (0.528) we can assume that in the case of the heat risk awareness index we could not expect an “acceptable” rather a “minimum tolerable” level of reliability.[159]

Table 4 Development of the scoring system for the heat risk awareness index

Factors of awareness	Scoring System (Yes = 1 Point)
Awareness of heat induced health impact in the city	1
Discussion about heat-adaptation at Institution	1
Interest in heat-adaptation	1
Receive heat warnings	1
Responsibility of heat-adaptation	1
Heat adaptation action plan	1
Heat adaptation training	1
Personnel protection against heat	1

Score of the Awareness-Index:

- 8 = excellent
- 7-6 = appropriate
- 5-4 = acceptable
- 3-2 = tolerable minimum
- 1-0 = not tolerable

3.5.2.2. Heat Adaptation Index

The heat adaptation-index was constructed to assess the level of heat adaptation actions at HCP. Based on the qualitative expert interviews and the comprehensive literature research the heat adaptation index is a screening instrument for intervention measures. It consists of 17 items which cover the different domains a) heat adaptation of the architectural surrounding (11 items e.g. air-conditioning, garden, roof etc.) and b) interventional heat actions modalities (6 items e.g. fluid intake etc.).

a) Domains of the adaptation of the architectural surrounding are:

- Air-conditioning, open windows, reflective colour of the roof surface, green roof, facade greening, garden/park areas, sun protection devise, hygrometer, south alignment of the patient rooms, heat isolation.

b) Domains of the interventional heat actions modalities are:

- fluid intake, fluid balancing, cool washing, flexible patient transfer, Clothing, adaptation of the ambient temperature

3.5.2.2.1 Weighted Score System Heat Adaptation Index Part A

Opposed to the heat risk awareness index the adaptation index was split into a weighted and an unweighted part. The Aspects of part a) “architectural surrounding due to heat adaptation" need to be weighted because of the different level of impacts in relation to the reduction of heat related health risks for patients/residents. For instance, air-conditioning in patients/residents rooms is more effective due to the reduction of heat risk factors of clients than the implementation of hygrometers in patient/resident rooms.[160] The weighting process of the different heat adaptation measures are conducted by expert rating. Therefore 13 experts were asked to rate the impact of the different „architectural surrounding" measures that have an influence on heat adaptation of health care institutions. Further input was generated by the scientific findings of the review of Salonen and Colleges (2013). They reviewed and summarized physical factors of the indoor environment in health care facilities that affect human health and wellbeing.[160] The value of the heat adaptation rating for each item was a scale from 0 (no heat adaptation effect) to 10 (excellent heat adaptation effect).

Table 5: Results of the adaptation measures score due to weighting by expert rating

Heat adaptation measures (architectural surrounding)	**Rating in points 0-10 (mean value)**
Every patient room has got air-conditioning	10 (9.5)
For patients it is possible to stay in air-conditioned rooms	5 (5.2)
Windows in patient rooms can be opened	3 (3.4)
Light colour of the roof surface (reflective)	5 (5.1)
Planting of the roof (Green Roof)	5 (5.1)
Facade greening	5 (5.2)
Garden/park areas	5 (5.3)
Sun protection devise of the patient rooms (e.g. shutters)	3 (3.4)
Hygrometer thermometer at the patient's room	2 (1.9)
South alignment of the patient rooms	5 (4.9)
Heat isolation	5 (5.4)

Due to this evaluation of the experts it was possible to weight the different heat adaptation measures regarding their effect size of heat risk reduction for patients/residents. For instance, the experts recommended that the highest influence of heat risk reduction for patients/residents is the implementation of air-conditioning in every patient/resident room of the health care institutions.

To measure the answers from the HCP the value of the index of part a) of the heat adaptation index the scoring system is as followed: participants that answered the query of heat adaptation measures with “present” score points (see table 9). On the other hand if the HCP cannot confirm (“not present” or “not known”) if they have that particular heat adaption measure than they do not score points.

3.5.2.2.2 Reliability of the Heat Adaptation Index - Part A

The reliability of Part A from the adaptation index was evaluated by statistical analysis. The domain “architectural surrounding” includes the following items

Table 6: Results of reliability test for the development of heat adaptation part A index

Items Name	Corrected Item Correlated Total	Cronbach`s Alpha if Item delated
Every_Room_Airconditioning_Index	0.175	0.101
Possibility_Stay_Aircoditioned_Room_Index	0.318	-0.018
Possibilty_Open_Window_Index	has 0 variance	Has 0 variance
Light_Colour_Roof_Surfaces_Index	0.009	0.209
Planting_Roof_Index	-0.172	0.281
Facade_Greening_Index	0.075	0.161
Garden_Park_Index	-0.078	0.237
Sun_Protection_Devise_Index	0.255	0.110
Hygrometer_Index	0.196	0.136
South_Alignment_Patientrooms_Index	-0.064	0.261
Heat_isolation_Index	0.255	0.128

The reliability test calculated with n= 29 (82%) presented a relatively appropriate overall reliability coefficient of 0.263. The corrected items correlation ranged between -0.172 and 0.318 and if we delete one particular item from the scale the value that Cronbach's Alpha would have ranged from -0.018 to 0.281. Due to this procedure we could not get a relevant increase of Cronbach’s Alpha if one executes particular items. In addition. the Item “Possibilty_Open_Window_Index” has 0 variance and is rejected from the test.[152] This is because all participants answer the question equally with “yes”. According to the guidelines of Blanz (2015) the interpretation of Cronbach`s Alpha test

(0.263) we can assume that in the case of the Part A of the heat adaptation index we could expect an "unacceptable" level of reliability.[159]

3.5.2.2.3 Unweighted Score System- Part B (Heat Adaptation Index)

The domains of part b) "interventional heat actions modalities" are developed by the newest updated recommendations of WHO regional office for Europe (2011) for medical professionals and care providers due to health conditions that create high risk of health effects from heat. In addition, experts recommended further domains of heat intervention modalities.[113] For the selection of the evidence-based health protection during hot weather by the HCP the meta-analysis of Hajat and colleges (2010) was taken into account.[161] In this Review, they report current epidemiological and physiological evidence about the most commonly provided heat-protection advice, and make recommendations about the optimum clinical practice that are expected to reduce health problems associated with current and future hot weather.[161] Due to this recommendations 6 items were identified that give an appropriate overview about the level of health care provider's heat interventions modalities. Based on the WHO recommendation sheet "Public Heath Advice: on preventing health effects of heat" (2011) each item is treated equally in the calculation of the part b) of the heat adaptation index.[113] We cannot determine any difference of the effect size on improvement between evidence interventions that increase the adaptation modalities of care providers due to heat. Therefore the Part b) is measured equally. The health care institutions had to specify their answers if the take action on an "individual decision" or if the act because of a standard operating procedures. The purpose of "heat guidelines" is to establish standards and responsibilities for minimizing the effects of heat stress to patients/residents but also to health care staff. The score system of this study assumes that implanted guidelines for heat intervention are sufficient due to the heat adaptation of health care institutions rather than individual decision. Corresponding providers that "take action due to standard operating procedures" score two points, other providers who "take action due to individual decision" score one point.[159]

Table 7: Development of the scoring system for the heat risk adaptation part B index

Factors of Heat Adaptation (Part B)	Scoring System (in Point)
Modalities of heat intervention:	Maximum Score: 12 Points
Increased fluid intake	max. 2
Monitor fluid balancing	max. 2
Multiple cold washing	max. 2
Vulnerable patients will be transferred into "cooler surroundings"	max. 2
Qualified personnel take care of appropriate clothing for patients	max. 2
Pull down the shutters at day and ventilation at night	max. 2

3.5.2.2.4 Reliability of the Heat Adaptation Index - Part B

Indeed as in the case of the awareness index the reliability of Part B from the adaptation index was evaluated by statistical analysis. The domain "heat modalities of heat interventions" include the following items:

Table 8: Results of reliability test for the development of heat adaptation part B index

Items Name	Corrected Item Correlated Total	Cronbach`s Alpha if Item delated
Increased_Fluid_intake_Index	.498	.730
Monitor_Fluid_Balancing_Index	.481	.734
Multiple_Cold_Washing_Index	.531	.721
Transfer_into_Cooler_Surroundings_Index	.464	.745
Appropriate_clothing_Patients_Index	.559	.716
Pull_down_Shutters_Index	.525	.722

The reliability test calculated with n= 28 (80%) presented a relatively appropriate overall reliability coefficient of 0.769. The corrected items correlation ranged between 0.464 and 0.559 and if we delete one particular item from the scale the value that Cronbach's Alpha would have ranged from 0.716 to 0.745. Due to this procedure we could not get a relevant increase of Cronbach's Alpha if we execute particular items. According to the guidelines of Blanz (2015) the interpretation of Cronbach`s Alpha test (0.769) we can assume that in the case of the Part B of the heat adaptation index we could expect an "acceptable" level of reliability.[159]

Final Heat Adaptation Score

As a final step we combined the weighted heat adaptation index part a) and the unweighted heat adaptation part b). As a result the heat adaptation index consist of a scale from 0 till 64 points:

Score of the Adaptation Index:
53-64= excellent
40-52= appropriate
27-39= acceptable
14-26= tolerable minimum
0-13= not tolerable

4 Results of the heat awareness/ adaptation survey

In this chapter the results of the heat awareness/ adaptation survey will be presented.

4.5 Sample Characteristics

A total of 256 care provider personnel were invited to complete the survey, from whom a total of 35 (27 via e-mail; 8 via telephone call) valid responses were received, giving an overall response rate of 13.7%. The most HCP are retirement homes (80%) followed by hospitals (20%).

HCP of all 12 administrative districts participated in the survey as shown in appendix 9.5. Overall 63% of HCP with the capability to provide 50 till 150 patients or residents participate in the study. Conversely only a few of major HCP (6%) that provide beds for >1000 and 501-1000 patient/residents and health care institution which are able to accommodate 151 till 250 and 251 till 500 patients/residents (27%) answered the questionnaire (n=34).

Most respondents (n=34) were managers (80%) followed by quality managers (20%) and social workers (3%). The large majority of the participants (85%; n=33;) had been in their current professional role for more than five years, only a few of them have less than two years working experience (9%) and 6% of them have professional experience between two and five years (n=33). More than half of the participants are employed at their current health care institution more than 5 years (50%), followed by participants who are employed two till five years (35%) and less den two years (3%) at their healthcare institutions(n=34).

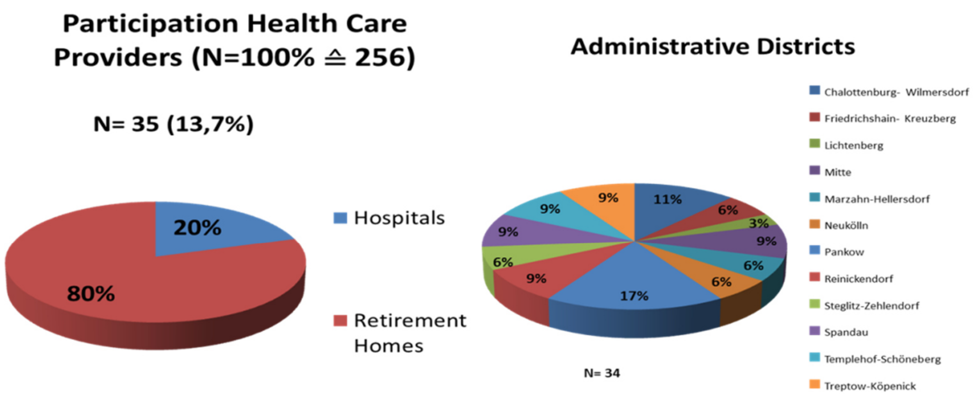

Figure 10: Kind of HCP and district were the healthcare facility is located in Berlin.

4.6 Awareness of Heat Risks

A high proportion of respondents (76%) demonstrated that they were aware of the heat induced general health impact in the city of Berlin. Conversely 15% of the participants are not aware of the heat related health impact of their city and 9% do not wanted to comment on this question(n= 34).

More than 90% agreed that heat is (very (91%) or slightly (6%)) likely to cause patients/residents who are already ill to become sicker'. A few of the respondents (3%) do not think that heat have an additional impact on the well-being of the patients/residents (n=34). Overall, when asked if they ever discussed about heat adaptation at their institution because of the increased temperature per year. Eighty-eight percent of the responders affirmed that "heat" as a topic was discussed already at the institution. Less than one quarter reported that heat was not discussed (6%) or they do not know (6%) (n= 34).

More than 80% of respondents "very" (56%) or "slightly" (29%) observe an increase in patient/resident care during hot days (°C >30). Whereas one-eighth of the participants did "not" (9%) observe (or did "not know" (6%)) such an increase of patient/resident care during heat days (n= 34). A "very" (15%) or "slightly" (32%) increased need in medical staff requirements due to an increase of patient/residents care during hot days (°C >30) was determined by less than half of the respondents. For the half of the respondents increased need of medical staff requirements have "not" (29%) (or they did "not know" (24%)) taken place at their institution (n= 34). Overall, three quarters of all institutions are "slightly" (49%) or "very" (18%) concerned about the quality of care due to the increase in frequency and duration of hot days (°C >30) in the future. On the other hand 18% are "not" concerned about the quality of care due to these future circumstances and 15% did not wanted to comment this question (n= 33).Seventy percent of the responders are interested to get more information about heat adaptation of their institution. However 15% of them did not want to get information and also 15% did not wanted to answer this question (n= 33).

4.7 Information and Communication

The German Weather Service set up a heat health warning system as consequence of the hot summer of 2003. Its purpose is to predict heat stress periods, issue early warnings to the public, and prevent negative health effects.[128] According to the German federal office of environment (Umwelt Bundesamt) “early warnings are issued to the Länder and if necessary, to counties, who will authorise regional measures suited to local conditions (e.g. for the elderly and those with impaired ability to react due to residence in nursing homes and hospitals) and issue recommendations for dealing with the heat (e.g. to the general public. A neighbourhood-based support network for the elderly, sick or infirm who live alone or without care is important in this regard).”[162] In Berlin the spread of heat warnings and heat information to healthcare institutions the responsibility rests with the federal state of Berlin. Furthermore, in Berlin only official weather warnings are forwarded, heat information’s are not spread to health care intuitions. Hospitals and retirement homes will not be obligated to subscribe a newsletter for heat warnings or other measurements that inform health care institutions about actual heat situations in Berlin.[130]

4.7.2 Recipients of heat warnings

When asked the respondents if they receive heat warnings though an institution such as, department of health or DWD, less than half of the participants (45%) of the survey receive heat warnings (n=33). More than half (57%) of these HCP that receive heat warnings (n=14) stated that they get informed via e-mail. Another communication channels are media (22%) followed by others ((21%) post, SMS, homepage DWD). Only a few of these institutions (30%) have got a newsletter abonnement of the German weather service (n=14).

4.7.3 Non-Recipients of heat warnings

Moreover, half of the health care institutions that do not receive (49%) heat warnings or do not know (6%) if they receive such warnings (n=34). The overwhelming majority of these HCP that do not receive heat warnings (n=19) indicated that they will get informed best if the contacted via e-mail (89%) followed by media (9%).

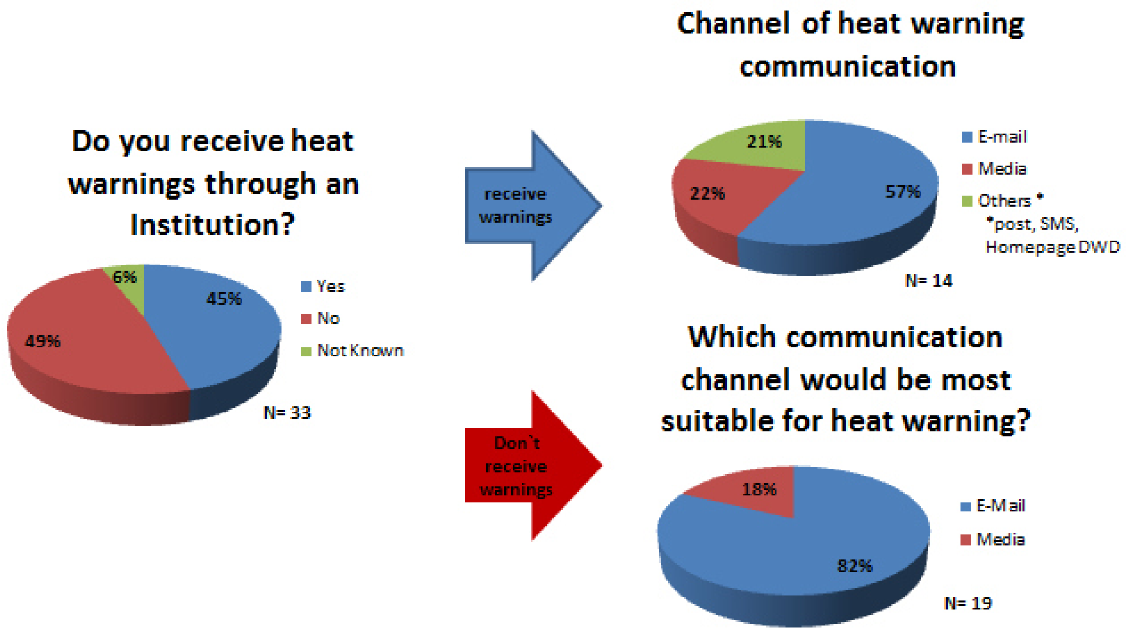

Figure 11: Distribution of HCP that receive or not receive heat warnings and their cannel of heat waring communication.

In addition all of the responders (n=30) were asked of their opinion if heat warnings are helpful to implement heat adaptation measurement to reduce the risk of heat stress for patients/residents. A majority of this sample (74%) consider that heat warnings are helpful to implement measurements against heat. On the other hand one quarter of the participants do "not" (22%) or do not know (3%) if such heat warnings are helpful to implement measurements.

4.8 Administration and Competences

Less than one quarter of the respondents (23%) stated that they have got a professional authority that is responsible for heat adaptation at the health care institution (n=31). The majority of the HCP do not have a professional authority that is responsible for heat adaptation (58%) or they do not know (19%) if a professional authority care about heat adaptation.

HCP that implemented a professional authority for heat adaptation (n=7) determine that the occupational departments: management, quality management, health care expert, facility management and an occupational safety committee are responsible for this task.

On the other hand, HCP that do not have implemented a professional authority for heat adaptation (n=24) determine that the management, quality management, health care expert, facility management or others could be the possible target group to cope with the task of heat adaptation.

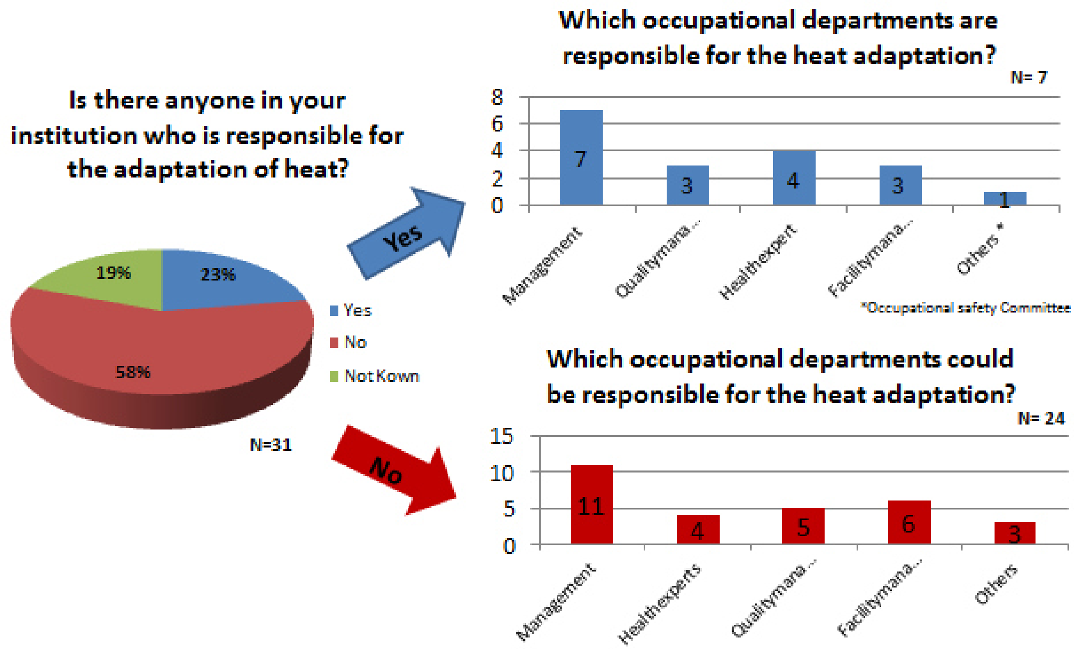

Figure 12: Distribution of heat adaption responsibility within the HCP facility and the type of occupational department that have/or could be responsible for heat adaptation.

4.9 Modalities of Heat Intervention

A low proportion (31%; n=32) of respondents set out that they have implemented a heat action plan at their institution. However, half of the respondents (50%; n=32) do not have a heat action plan for hot days (>30 °C) or do not know if they have one. Some of the respondents (16%; n=32) stated that the implementation of such a heat action plan is in process. Respondents that have implemented a heat action plan elucidated that they use measurements of heat intervention like preventions of dehydration, protocol of fluid intake, outdoor and indoor shading system, air-conditioning for employees and light blankets for the patients/residents. More than half of the participants (52%) that do not have a heat action plan or do not know if they have one (n=21) believe that there is no need to implement a heat action plan in order to avoid the consequences of heat days at their institution. On the other hand twenty-nine percent of the HCP that do not have a heat action plan believe that there is a need to implement a heat action plan at their institution and one quarter of the responders (19%) do not want to comment this question.

More than half of the responders do not provide (42%) or do not know if they provide (13%) educational training for the medical staff regarding the instruction of heat prevention measurements. Fourth- five percent state that they provide such an educational training (n= 31).

Not merely the patients/residents have to be protected from heat stress and health risks of hot weather days, also the medical staff need measurements that support their “performance” during their shift work at the institution. A majority of the responders (94%) stated that they already implemented measurements that support the “performance” of their health care professionals during hot days. Only a few of the responders (6%) do not have any measurements to support the staff (n=31). Most of the responders that have implemented measurements to support the staff elucidated that beverages, fruits and ice are freely available for the medical staff at all times or at hot days. A responder stated that the institution proposed to liberate the provision of the working uniform of the health care staff.

To generate an exact level of knowledge about the heat adaptation modalities of the HCP this survey asked what kind of measurements are considered that are undertaken by the institution in order to protect patients/residents from heat related health hazards. As described in table 7 the categories of implemented measurements shall evaluate the degree of implementation of heat intervention and prevention procedures at the health care institutions.

Table 9: Distribution of the heat adaptation modalities of the HCP

Heat Intervention Method	Qualified Personnel take action regard to SOP`s (N)	Qualified Personnel take action regard to individual decision (N)	No (N)	Not Known (N)
Increased fluid intake (n=31)	15	16	-	-
Monitor fluid balancing (n=30)	20	10	-	-
Multiple cold washing (n=28)	1	19	4	4
Vulnerable Patients will transfer into “cooler surroundings” (n=29)	3	15	9	2
Qualified Personnel take care of appropriate clothing for patients (n=30)	12	19	-	-
Pull down the shutters at day and ventilation at night (n=31)	17	12	-	1

Most of the HCP developed important measurements such as increased fluid intake and monitor fluid balancing etc. that reduce heat related health risks for patients/ residents on a standardized- or individual decision (health care staff) level. The least often practiced intervention is “transporting clients to cooler places”.

4.10 Building structure, equipment and surrounding

An important part of heat prevention at stationary healthcare institutions is the building structure. Measurements like air-conditioning ensure the reduction of heat stress for patients/residents significantly.[160] Furthermore, the building equipment’s of HCP such as, sun protection devises or hygrometer serves as effective measurements to create a pleasant climate for the wellbeing or identify the environmental hazard of heat. According to Balbus and colleges (2015) green spaces, rooftop and vertical gardens, and using light-coloured building can help to reduce temperatures at the microclimate level.[163] HCP that implemented such heat adaptation strategies reduce the indoor temperature of their institutions. Hereby, this survey wanted a responds of the enquiry “what kind of heat adaptation measurements are present at the health care institution. As described in table 5 the categories of implemented measurements shall evaluate the degree of implementation of heat adaptation procedures at the health care institutions.

Table 10: Distribution of building structure that prevents heat- health related risks at HCP facilities.

Heat Adaptation Measurements	Present (N)	Not Present (N)	Not Known (N)
Every patient room has got air-conditioning (n= 29)	1	28	-
For patients it is possible to stay in air-conditioned rooms (n= 29)	7	22	-
Windows in patient rooms could be opened (n= 30)	30	-	-
Light colour of the roof surface (reflective) (n= 29)	13	10	6
Planting of the roof (Green Roof) (n= 30)	5	23	2
Facade greening (n= 30)	4	25	1
Garden/park areas (n= 30)	26	4	0
Sun protection devise of the Patient rooms (e.g. awnings) (n= 29)	25	3	1
Hygrometer thermometer at the Patient room (n= 29)	8	18	3
South alignment of the patient rooms (n= 29)	13	12	4
Heat isolation(n= 30)	20	4	6

Only one health care provider implemented air-conditioning at every patient/resident room. The rest of the responders do not have air-conditioning for every patient/resident room. However, seven of the participants stated that patients/residents have the possibility to stay in air-conditioned rooms at their institution. Facade and roof greening only supported from a view providers. The majority of the responders reported classic adaptation measurements for instance awnings or the windows could be opened.

4.11 Preparedness of Heat Events

The last question of the survey aimed at the feeling of preparedness against future heat events. Whereas 29% of the participants feel “very” and 68% feel “slightly” prepared, only 3% responders feel “not at all” prepared against future heat events (n= 31).

4.12 Heat Risk Awareness-Index

On the developed heat risk awareness scale the average of the responders reach 4.9 (n=29; SD= 1.6) points. This outcome can be interpreted as an acceptable level of heat awareness regarding this sample. In order to estimate the value of information the data was categorized into five groups of awareness of heat health risks: not tolerable (0-1), tolerable minimum (2-3), acceptable (4-5), appropriate (6-7) and excellent (8-9). Fortunately, none of the HCP achieved a “not tolerable” level of awareness of heat risks. However, almost a quarter of participants attained a “tolerable minimum” (21%) of awareness due to heat. The majority of HCP reach an “acceptable” (41%) or “appropriate” (35%) level of heat risk awareness and only one healthcare provider gained an “excellent” (3%) score of heat risk awareness.

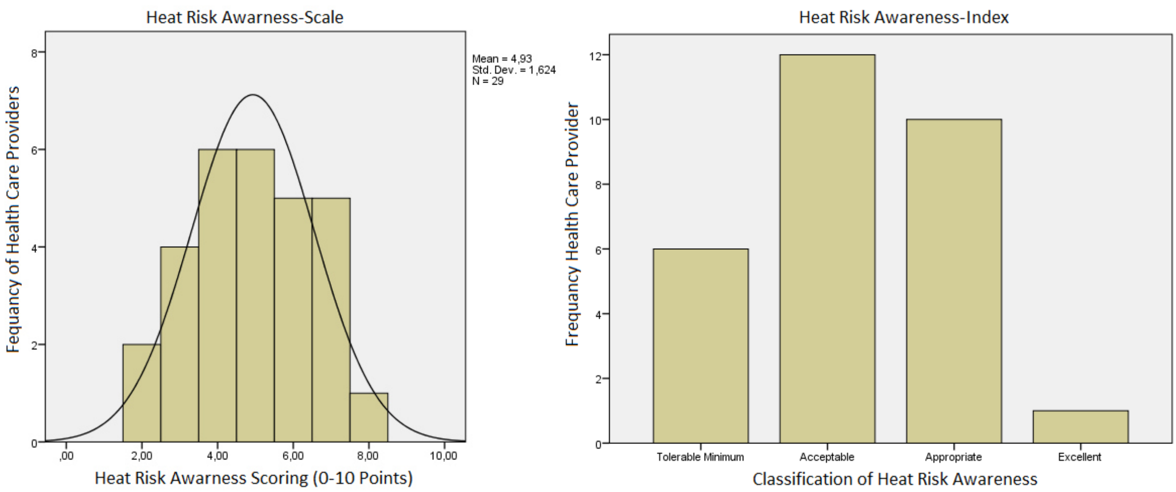

Figure 13: Histogram of the heat risk awareness scale and the standardized categorization of the developed heat risk awareness index.

4.13 Heat Risk Adaptation-Index

Overall, the HCP archived a mean of 30 Points (n=28; SD= 7.4). This result can be interpreted as an “acceptable” adaptation against heat related health risks. Similar to the heat risk awareness-index development procedure a heat risk adaptation-index was developed in order to characterize and evaluate the capacity of HCP coping- and adaptation strategies against heat risks. The categorization was split into five groups of adaptation of heat risks: “not tolerable” (0-13), “tolerable minimum” (14-26), “acceptable” (27-39), “appropriate” (40-52) and excellent (52-65).

No one of the HCP that participate in this study (n=28) had achieved neither “excellent” nor “not tolerable” result on the heat risk adaptation- index. The average mean of the cohort scored 29.5 (SD= 7.4) points out of 65. However, most of the responders attained a “tolerable minimum” (36%) or an “acceptable” (61%) heat risk adaptation score. Only one healthcare provider reached an “appropriate” (4%) result.

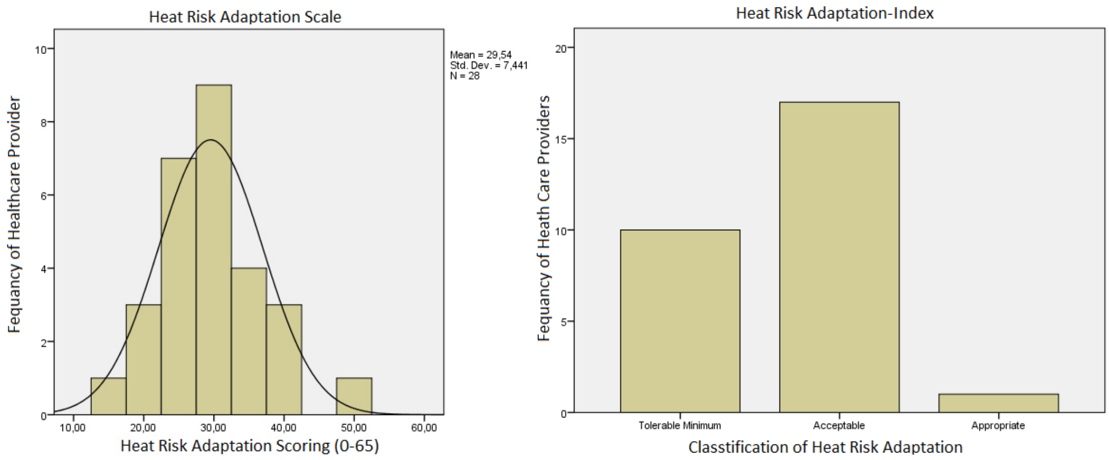

Figure 14: Histogram of the heat risk adaptation scale and the standardized categorization of the developed heat risk awareness index.

4.14 Hypothesis 1:

- Association between Heat Risk Awareness and Heat Risk Adaptation

This survey was conducted to examine if the stationary HCP already gained awareness about heat risk of their patients/ residents, than they will increase their adaptation and coping skills due to heat risks. Therefore, the H1 of this study assumes that the higher the level of heat risk awareness is, the higher are the heat risk adaptation measurements of the HCP. By linear regression analysis of the heat risk awareness scale and heat risk adaptation scale it has to be stated that any associations cannot be observed ($F [1.24]= 1.563$; $p = 0.223$) within this study sample. The p- value of the correlation is above the significance level of 0.05. Assuming that a p-value of 0.223 is not statistical significant[164] we can conclude that there is not enough statistical evidence that indicates that awareness due to heat risk of patients/ residents in this sample is correlated with an increase of heat adaptation measurements at stationary health care institutions. Therefore we can draw conclusion that the H1 hypothesis can be rejected within this particular study sample.

4.15 Hypothesis 2:

- Association between increase in patient care during hot days (30°C) and an increased need of health care staff recruitment during those days.

By correlating the increase in patient care during high temperatures and the increased need of health care staff recruitment during those days, it has to be stated that a significant correlation can be observed ($r = .567$. $p = .001$. $n = 34$) due to this study sample. According to Zah (1998) the effect size of r= 0.567 in this correlation correspond to a strong effect.[151] This determine a strong association that stationary HCP which recognize an increase in patient care during hot days (30°C) also determine an increased need of health care staff recruitment during those days. Therefore we can draw conclusion that the H1 hypothesis is fulfilled within this particular study sample. The demand for care of patient/resident health conditions during hot days and the need for available health care professionals seem to be an essential priority to insure the quality of health care.

5 Recommendation for Heat Action

5.5 Results from Expert Interviews

As described in the methodical chapter the 13 semi-structured interviews with stake holders were structured and content analysis according to Mayring[24] was conducted to generate the cluster of innovative recommendations for heat action for the health care setting. The following recommendations are made for consideration as a result of the findings of this research study. We could determine key areas and show a systematic cluster of themes. The pathways of the heat action strategies for recommendations will be presented in the following chapter.

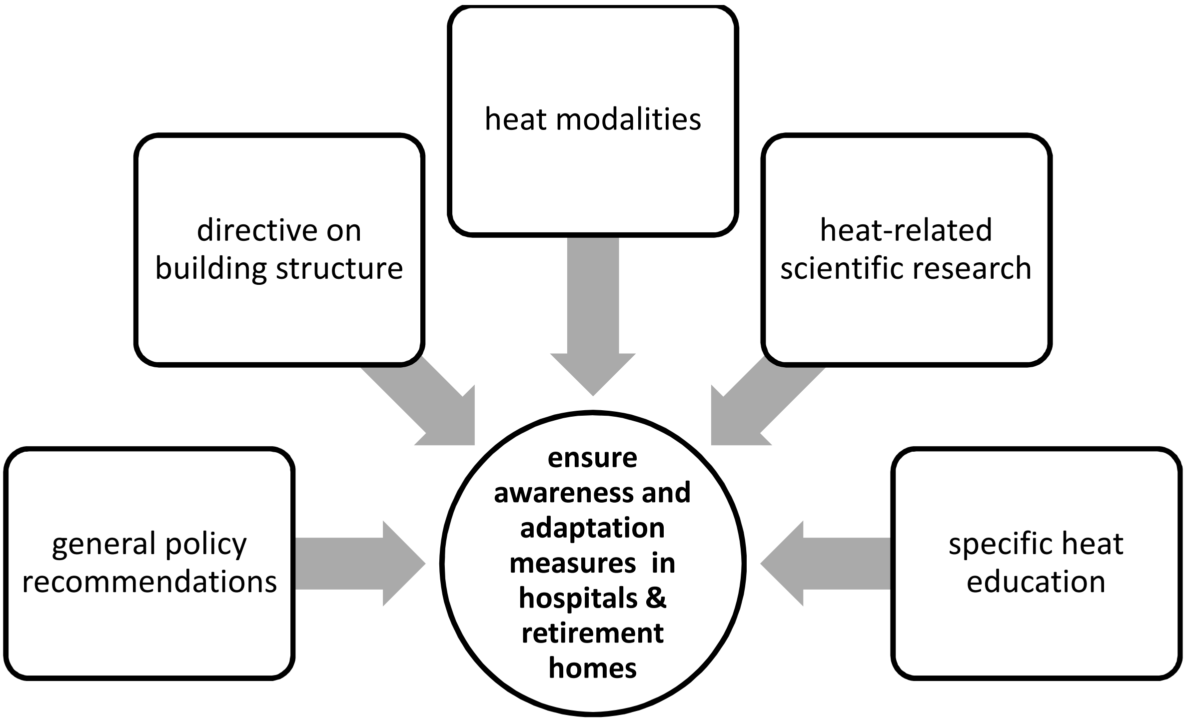

Figure 15: Results of the context analysis by clustering the themes of the expert recommendations

5.6 General policy recommendations

A consistent policy for the management of resident facilities and hospitals during periods of high temperatures should be developed and triggered from both sides on the political level and the HCP. Within the new policies a continuous monitoring and review of response to high temperatures should be part of regular continuous improvement strategy. A communication strategy driven by the health department of Berlin should be developed for HCP and disseminated prior to expect days with high temperatures. A health care provider heat awareness campaign needs to be conducted prior to the summer season. Policy guidelines on emergency management may be beneficial in assisting in the development of heatwave planning guidelines and could be considered in the development of policies that include the issue of high temperatures. Disaster / Emergency planning which includes response to high temperatures should be a part of Resident and Hospital provider accreditation standards.

5.7 Directive on Building structure

Neither in the legislation on minimum residential home standards (§34 HeimMindBauV), nor in the legislation for hospital building construction (KhBauVO) the regulation do not provide mandatory directives for HCP to cope with heat in Berlin. The modification of mandatory heat adaptation requirements is of importance; especially these legislations would have had a major impact of adequate reviews. Possible modifications regard to heat adaptation can be for instance, the obligation to place shutter in patient rooms to degrease the air temperature in patient rooms during the day. HCP should be aware of the supply chain if they invest in the building infrastructure of their facilities. Heat adaptation measures of health care facilities such as inter alia: shutters, air-conditioned patient rooms or light roof surfaces can have a significant impact on the sensation of thermal comfort and therefor on the well-being of residents and health care staff.[165] This gives the health care provider a unique competitive advantage in the health care market. In Germany we can observe two imported impacts which results in a significant pressure on HCP at the health care market. On the one hand the demographic change will lead to an absolute increase of patients with chronic non communicable disease. At the same time the age-spectrum of patients with these diseases will shift towards older ages. This situation leads to an increase in provision of care.[166] On the other hand Germany has a lack of well-trained personnel in the healthcare provider setting. According to the German Federal Employment Agency (2014) there is a need for professionals in healthcare. The category includes doctors, nurses and therapists. The rising demand for patient care and the lack of qualified professionals represent challenges that requires solutions for HCP to survive on the health care market.[167] The investment of heat adaptation is one possible solution to cope with those challenges. The developments of measures that relate to heat adaptation maybe enhance a comfortable atmosphere for patients or residents and healthcare staff during hot temperatures. Therefore the well-being of the patients and residents that live- and the performance of the health care staff that work in these health care facilities may will significantly be less influenced during heat events than facilities that do not adapt to such events.[138] This possible benefit act as an advantage opposed to the HCP who do not invest in heat adaptation measures (Fig. 16).

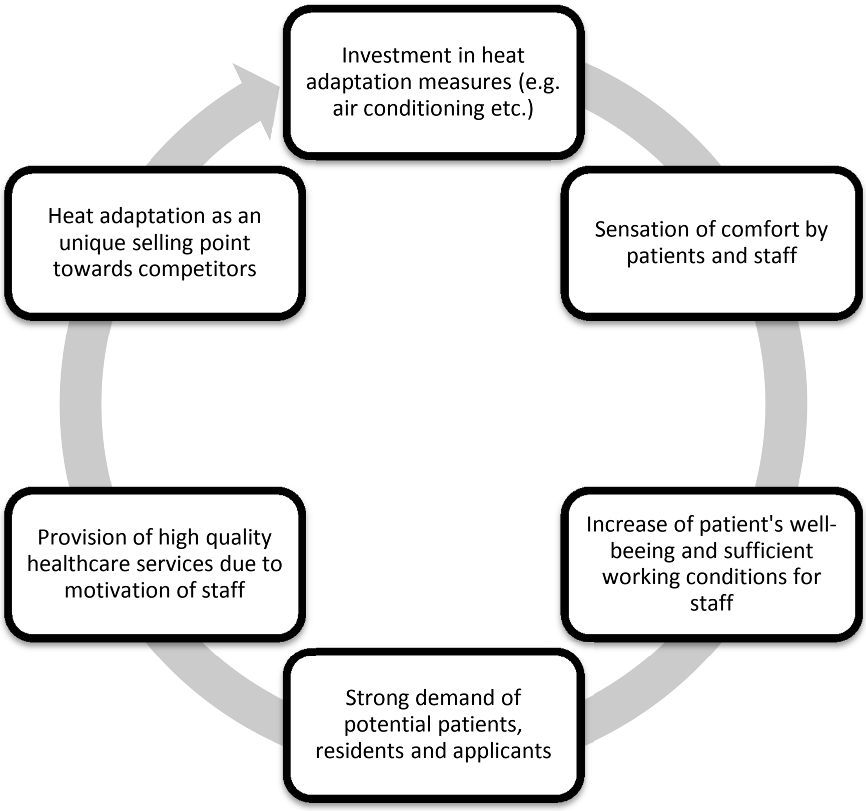

Figure 16: Supply chain of heat adapted health care facilities due to building structure

5.8 Chances in Heat Modalities

Best practise examples, such as the “Klimaanpassungsnetzwerk der Modellregion Hessen” (KLIMZUG direct) have already been tested. Aim of this project is to certify HCP with a seal of quality due to heat adaptation.[146] The seal of quality defines quality standards for the health care and the qualification of the health care professionals as well as measures for the optimization of work-organizational aspects and certifies their implementation with a certificate. Thus certification of the HCP the quality seal represents a possible sustainable competitive advantage and provides an incentive to implement the defined measures in the daily work routine. The German technical service of the healthcare insurances (MDK) has got the reasonability to measure the quality of care of any single healthcare provider in Germany. According to the MDK

Guidelines for proof of quality for stationary HCP (§§ 112, 114 SGB XI) heat is indirect proofed for instance, taking into account the fluid balancing protocol.

However, the MDK do not directly implement the issue of “heat adaptation actions” into their quality catalogue (check-up list) if they are doing their quality inspection in hospitals and retirement homes. Such an option is not provided by the MDK at present. The MDK is undoubtedly a key player in auditing profession of HCP’, and as such it is as responsible as anyone else for finding answers how HCP can adapt to heat.

Further recommendation of heat modality is an implementation of an action plan in place, and be prepared for an extreme heat event. Measurements like a pre-summer checklist of heatwave preparedness will possibly consider the adaptation of events. HCP need to have a strategy outlining how and where to move residents/patients safely and efficiently during hot days. In addition, HCP need to have a defined strategy for the provision of additional fluids during extreme heat (volunteers, additional staff) and need to have a register of residents who take medications which may potentially be affected by extreme heat dehydration or over-hydration.

5.9 Need for heat-related scientific research

There is a need for a systematic approach that focuses on metrological and epidemiological data to identify possible dysfunctions in humans due to climatic circumstances. In order to generate knowledge about heat outcomes and possible adaptation strategies at the health care settings. Further investigations such as, the INKA-BB subproject 5,[136] that concentrates on heat warning and intervention systems for health care and disease management in Berlin and Brandenburg is needed. Based on the results of this clinical trial it was possible to estimate that heat stress increase physical impairments of COPD patients and telemedicine care helps to reduce the frequencies of the physical impairment in that patient cohort. Thus it appears that, further development of tele-monitoring is intended to complement the health care supply as an adaptation strategy to climate change in the field of health in urban areas. This is precisely why evidence based research on heat related health outcomes are fundamental for guideline decisions. Therefore more evidence based research has to be supported. In particular there is a need for a measurement of cost-effectiveness that aimed at preventing heat-related morbidity and mortality among the institutionalised patients and residents.

One possible stakeholder for the research of heat-related care is the German Network for Quality Development in Care's (DNQP). This Organisation is a national network of nursing experts committed to the quality of nursing care. The overall aim of the DNQP is the advancement of nursing care quality in all settings of care based on practice and expert standards. So far, this network does not investigate directly into heat-related care outcomes. If heat related standards in healthcare settings can be achieved then there is a potential chance to raise the level of quality of care in health and social care facilities for patients and residents significantly.

5.10 Specific Heat Education

The education and training of health care staff is one of the most important measures to structure a qualitative high level of heat adaptation. Up-skilling staff on the importance of caring for the heat vulnerable individuals in periods of high temperatures should be a part of regular in-service for HCP. This training should be made mandatory prior the beginning of each summer season. Sustainability and resiliency actions should be viewed as overlapping components of the same adaptation process. The economic and quality of life benefits of sustainability are significant. Examples include reductions in costs to facilities, increased energy and water conservation, reductions in greenhouse gas emissions, improved air quality, and healthier patients, staff, and communities. Education of professionals in health care facilities offers numerous opportunities for synergistic outcomes, possibly lowering the cost of the resiliency and sustainability improvements that allow facilities to continue providing services to the community during adverse events.

Currently only a few pilot projects of heat educations for HCP are available in this setting. In the past the Charité – Medical University Berlin started the project „Klimaanpassungsschule“(KAS). This program provided health care professionals with education and training to sensitive the target group about the impact of climate change. Leading experts from a wide range of areas informed about measures that taken into account due to the prevention and care of weather-related health risks and damage. In order to promote the topics adaptation, reconnaissance and treatment options of climate change into the focus of the health care professionals, they introduced the contents into other training measures in the field of internal medicine, dermatology or pneumology. Thus, the participants should be able to independently take decision in difficult situations (heat, flooding, strong air pollution) and to motivate and guide other staff and colleges to be aware of environmental health factors. If empowered and properly trained, workers can help raise awareness of climate change and health risks more broadly, advocating for adaptation measures among facility leaders and within the broader community.[168] The education of climate change hazards like the continues increasing impact of heat in humans need a sustainable implementation in education grogram's of all health care professionals. Projects such as the KAS have to be developed continuously and should not be dependent on temporary monetary support.

6 Discussion

6.5 Main Findings

We could show that there is a strong association between the demand of care during high temperature days and an increased need for health care recruiting during those days. Furthermore we could not find a significant association between the heat risk awareness of HCP and an increased ability to develop adaptation measures at their facilities. Onley a few HCP get heat warnings though an institution and have a heat action plan as an appropriate measure to standardize modalities to cope with high temperature days. The overall survey participation is rather less. Thus any results given are rough approximations and have to be interpreted with caution.

6.6 Results in the Context of the current Scientific Knowledge

This survey-based study has investigated the awareness and practices of healthcare care providers that support the health of vulnerable in-patients and/or residents who temporary or permanent stay in hospitals or retirement homes in Berlin, regarding the health impact of high temperature. The study reported here is the first to provide empirical evidence about that theme for Berlin, Germany. Furthermore this study identified current procedures, strategies, knowledge and environmental factors (such as building design and cooling equipment), used in stationary healthcare institutions in Berlin which be adapted to prevent morbidity and mortality of patients/residents associated with heat. The outcome of this study is an index which allows determining and comparing the awareness and adaptation strategies of HCP regarding heat related health risks. Moreover, this study provided research evidence which strategies can be developed and implemented in stationary health institutions to increase the adaptation measures that are effective against the heat related health risk of patients/residents.

The response patterns of care managers were almost varied, and many care managers provided extensive replies to the open question on the implementation of heat adaptation strategies they expected. The study indicated that most survey respondents showed an adequate level of awareness that heat can be harmful for their clients (patients/residents). In accordance with other international studies which investigate also the awareness of health care institutions this result is similar to the general awareness of health care institutions.[169] [170]

Care managers generally agreed on the importance of cooling measures. However, this study determines only a few amounts of health care institutions that have air-conditioning in their patient- or in common rooms. This circumstance may be understandable, given the large investments required to buy and install many cooling measures (such as air conditioning), particularly in older buildings. Unfortunately, this low rate of investment does not ensure rapid progress in preventing heat-related mortality. A faster rate may be achieved by focussing on less expensive facilities such as reflective rooftop and heat-reflective windows. In Berlin the protection of patients and residents against high temperatures depended largely on the use of sun protection devises (e.g. sunshades) and the possibility to open the window by night.

Notable gaps in adaptation strategies were identified, including a lack of building and equipment heat adaptations in most of the institutions. More than three quarters of the responders do not implement a heat action plan. In accordance with the identified gaps the Australian study of Ibrahim and Colleges determined that few organisations were found to have existing heatwave plans, and responses to heatwaves were found to be mostly reactive and opportunistic, rather than proactive.[122] These findings lead to the assumption that heat action plans on an intentional level rather been settled at health care institutions compared to this study sample.

In addition to this poor outcome the responsibility to spread heat wave information rests with the federal state of Berlin. Only official weather warnings are forwarded. The heat information is not spread to health care institutions directly. Hospitals and retirement homes will not be obligated to subscribe a newsletter for heat warnings or other measurements that inform health care institutions about actual heat situations in Berlin.[130] In general, studies in other areas have reported mixed findings about the relationship between warning awareness and behaviour change.[156] A cross-sectional study found that 90 % of respondents were aware of heat warnings but many did not consider themselves to be attributable to heat risk and few reported changes in their behaviour as a result of the warnings.[92]

In this investigation we can observe a poor voluntary participation to register at the German weather service to require such heat warnings. Capellaro and Sturm (2015b) already provide evidence about the need of a body of knowledge with regard to empirical evidence and clear structural heat communication.[130] If the federal State of

Berlin changes the heat warning regulations for HCP into an active obligation when they should register at the DWD to access heat warnings. That provision possibly is an advantage to inform all HCP with necessary information and paves the way for heat action strategies of individual HCP.

Moreover, this investigation determine a strong association between the perceived increase in patient care during hot days (30°C) and an preserved increase of the requirement of health care staff during those days. These findings are possible indicators of a possible lack of quality control for care of patients and residents. Health care stuff are critically important to efforts aimed at increasing patient and public awareness of the effects of high temperatures on human health, anticipating threats to individual health, assessing communities' environmental health vulnerabilities, and lessening the health effects of climate change. A higher workload of care staff due to an increased care of patients/residents during hot days is a possible risk factor for possible shortage of care in particular for heat vulnerable target groups. The staff shortage of qualified health care stuff nowadays seems to be a challenge because of multifactorial reasons (e.g. low salary, occupational status, shift work, high working load etc.). In addition to the current staff storage challenges for HCP that already exists, high temperatures due to climate change also serves as further challenge of medical staff recruitment.

In this study, heat awareness was assessed from the perspective of health care managers. Thus, the results may not represent the views and experiences of healthcare and medical employees. Further studies among the staff that have patient or resident contact are needed to assess whether heat adaptation really make a difference to residents of institutions. Hospitals compared to retirement homes are diverse healthcare settings. Due to the opportunity of a fast treatment process and infrastructural circumstances hospitals are more likely to cope with heat-related health risks such as, dehydration or hyperthermia of their patients. Because of the differences in the ability to cope with high temperatures conclusion cannot be drawn for the comparison between both diverse healthcare settings.

6.7 Advantages, Challenges and Limitations

Due to the nature of the cross-sectional study design we cannot drew conclusion about a causal effect, because there is only one measurement point. The situation in Berlin may not be representative of other cities and regions in Germany. One reason is that the frequency and intensity of hot temperature days differs greatly across the country in relationship to the degree of urbanisation and the metrological circumstances. In Addition, the results may not be generalizable to other countries. The level of protection against hot days may vary between countries in relationship to climatic factors, the level of investment in institutional care, and the composition of the resident population. This study is also limited by a low response rate (n=35; 13%) and by the potential for responder and measurement bias. The low response rates from quality managers and managers of the health care institutions were particularly surprising, and may be due to a lack of time, or lack of interest in the subject matter. Furthermore, 80% of the institutions that participate in this survey were retirement homes. If we compare the distribution of the types of healthcare intuitions in Berlin, retirement homes were over-represented in this sample. The low participant rate is perhaps reflective of the widespread decline in response rates for all types of surveys.[171] Therefore, this study limits the ability to draw conclusions about individual professional groups or to generalize to other professions. Due to a lack of time and no funding body of this research the duration for the acquisition of the data took less than one month. When care managers were contacted with reminders, they reported lack of time as the main reason for not returning the survey. Non-response might be higher among institutions with less interest in the development and implementation of heat adaptation. If so, the implementation and the awareness of heat action planes in Berlin is less advanced than the study results suggest.

For this research the collection of the data stated at the 20th February 2017 and ended at the 15th March 2017. In this season of the year the weather conditions in Berlin are rather cold and damp with an averages temperature about 0°C, often with plentiful snow and frosty days when temperatures hover at or just below freezing and snow falls between December and March in the city. Based on that knowledge about the weather conditions during the survey duration we can discuss possible (underestimated) attitudes about heat-related health risks of vulnerable individuals. However, it would be of interest to repeat the survey in the summer time to investigate changes in awareness, knowledge and practices of health and care providers due to heat.

Furthermore, participation bias may have led to an over-estimation of awareness and knowledge if responders were more interested in the health impact of heat than non-responders. The anonymous nature of this study did not allow assessment of non-responders. Measurement error may have arisen through participant's misinterpretation of the survey questions.

Additional to the e-mail based survey a further telephone based surveys was conducted to increase the responders' rate. In an experimental comparison of web and telephone surveys Fricker and colleges determine that there are significant differences between web and telephone responders. Participants of the web survey have had fewer completed the online questionnaire; on the other hand, all those who were assigned to the telephone condition completed the interview.[172] Moreover, the web survey produced less item nonresponse than the telephone survey. On the basis of this knowledge, there is the possibility of bias due to these differences between web and telephone surveys probably reflect both inherent differences between the two modes.

Heat adaptation in hospitals and retirement homes is a multidimensional task and involve several professions that work in the contacts of these health care institutions. In this research the quality managers and mangers of the health care facilities were the target group of participation. However, this target group could not have the overall understanding and knowledge about this issue. Further research on the micro level of the institutions (facility management, nurses, GP´s etc.) is needed. Research on strategies for coping with urban heat waves has grown considerably in the last decade, but interdisciplinary differences limit the overall understanding of how HCP can respond to this ever increasing climate hazard for human health.

The index score of heat-awareness and heat-adaptation was developed by a mixed method approach and plausibility testes for both indices were conducted. The plausibility of the heat-awareness index and the unweighted score part B of the heat adaptation index showed statistical confidents, whereas the weighted score part A of the heat adaptation index demonstrated a low consistency. According to these findings the model seems to be inconsistent. These circumstance can partly explained by low participation rate (e.g. due to 0 variance within a question) of the survey and for this reason, the results must be interpreted with caution. A repetition of the plausibility test with a higher number of participation therefore will be of interest and would lead to a higher significance regarding the current findings. However, the think aloud expert interviews approach has high potential of innovation in this field of environmental health research to develop evidence based high quality questionnaires. This approach enables to integrate a multidimensional perspective on the degree of heat risk awareness and the adaptation measures applied in hospitals and retirement homes in Berlin. Further research can use the developed heat awareness and adaption index to observe the degree of knowledge and measurement strategies that are applied in HCP settings in other urban areas on a national and international level.

7 Conclusion

Climate change will increase the frequency and magnitude of extreme weather events and create risks that will impact health care facilities and in particular human health. Until now, limited research has been conducted that focus on the awareness and adaptation strategies of HCP regarding heat-related health impacts of patient in hospitals and residents in retirement homes in Berlin. This study contributes to this gap of knowledge.

Although the sample size included in this study is small, the HCP who did participate in this study raised many issues critical for the ongoing care of patient/residents who live in this city. There is evidence that high temperatures increase the hospital admission-rate significantly during that environmental circumstance and also there is evidence of significant higher mortality-rate during hot day’s especially in elderly people in Berlin. To do nothing is not an option. Continuous improvement strategies in both clinical and systemic processes are essential in order to adapt to the increasing demands of an elderly population in an increasingly climate with hotter days.

Further development and implementation of national heat plans and local heat protocols is essential to protect the institutionalized patients and residents against future increase of high temperatures. Potential areas of improvement include the cooling of buildings and training of staff. Future studies should assess the cost-effectiveness of measures aimed at preventing heat-related morbidity and mortality among the institutionalized vulnerable target group. Furthermore, research should also focus on the identification of specific risk factors in healthcare facilities with poor infrastructure, analyses of high temperature health improvement strategies and the development of tools to educate healthcare professionals about heat risks of their clients. Moreover, implementation studies in other countries would provide a broader evidence base to support the implementation of heat adaptation in different contexts. We hope that this study will assist in evaluating and managing the heat risk awareness and the adaptation measures in hospitals and retirement homes in Berlin.

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9 Annex

9.1 Expert Interview guideline

Interview Guideline:

Heat and Heath: Assessing the Awareness of Health Institutions due to Heat events.

I. Ist im Allgemeinen das Thema „Hitze und Hitzestress“ für Berlin Ihrer Meinung nach relevant?

II. Sind Ihrer Meinung nach Hitzeereignisse ein potenzieller „Störfaktor“ für den Versorgungsbetrieb in Gesundheitseinrichtungen?

III. Ist Ihrer Meinung nach eine Adaptation von Gesundheitseinrichtungen auf zukünftige Hitzeereignisse relevant?

IV. Sind Ihrer Meinung nach „Hitzeaktionspläne, Maßnahmenplanungen etc.“ für Gesundheitseinrichtungen relevant?

V. In wie fern ist Ihre eigene Einrichtung in Länder bzw. Bundes Konzepte bezüglich der Anpassung von Hitze eingebunden?

VI. Bei zu erwartender Überschreitung einer bestimmten "gefühlten" Temperatur am kommenden Tag ("starke Wärmebelastung" nach Deutschen Wetter Dienst-DWD) erfolgt eine rationalisierte Warnung des DWD.

Haben Sie ein Abonnement (Newsletter) vom DWD oder erhalten Sie Informationen über kommende Hitzeereignisse?

VII. Welche Reaktion erfolgt auf die Wahrung des deutschen Wetterdienstes?

VIII. Sehen Sie Zusammenhänge mit der baulichen Umgebung und Hitze?

Welche Möglichkeiten sehen Sie darauf Einfluss zu nehmen?

IX. Wie kann man Ihrer Meinung nach „das Bewusstsein – die Awareness“ gegenüber klimatischen Veränderungen wie beispielsweise „steigende Anzahl der Tage über 30 °C“ in den Gesundheitseinrichtungen erhöhen?

Daniel Engler
Cand. M.Sc. Health Science
Student Trainee / Studentischer Praktikant

[redacted]

[redacted]

9.2 Declaration of informant consent

Hochschule für Angewandte Wissenschaften Hamburg
Hamburg University of Applied Sciences

Vertraulichkeitserklärung

Forschungsprojekt	Climate and Health: Assessing and Coping with the Urban Heat Island Effects on Human Health in Major Cities
Durchführende Institution	Research and Transfer Center "Application of Life Sciences" Hamburg University of Applied Science/ Faculty of Life Science
Project Management	Prof. Dr. (mult.) Dr. h.c. (mult.) Walter Leal
Interviewer	Cand. M.Sc. Daniel Engler

Die aus dem Experteninterview erhobenen Erkenntnisse dienen zur Validierung des empirischen Fragebogens für das Forschungsprojekt "Climate and Health: Assessing and Coping with the Urban Heat Island Effects on Human Health in Major Cities." Im besonderen Focus des Interviews steht die Awareness und die Adaptation von Gesundheitseinrichtungen gegenüber klimatischen Veränderungen. Die Angaben des Interviewpartners werden aufgearbeitet und empirisch qualitativ ausgewertet.

Das Interview wird mit einem Aufnahmegerät aufgezeichnet und anschließend von Daniel Engler in Schriftform transkribiert. Für die wissenschaftliche Auswertung der Interviewtexte werden alle Angaben, die zu einer Identifizierung der interviewten Person führen könnten, verändert oder aus dem Text entfernt. Personenbezogene Kontaktdaten werden von Interviewdaten getrennt und für Dritte unzugänglich gemacht.

Die Teilnahme an diesem Interview ist freiwillig. Sie haben zu jeder Zeit die Möglichkeit, das Interview abzubrechen, oder Ihr Einverständnis in eine Aufzeichnung und Niederschrift des Interviews zurückzuziehen.

Hiermit sichert Ihnen Daniel Engler die oben aufgeführte Vorgehensweise bezüglich der Wahrung Ihrer personenbezogenen Angaben zu.

[redacted]

Ich bin damit einverstanden, im Rahmen des genannten Forschungsprojekts an einem Interview teilzunehmen.

X

Datum, Ort Vor-Nachname, Hz

Bitte senden Sie die unterschriebene Einwilligung an folgende Telefaxnummer + 49-40-42875-6079 oder E-Mail: Daniel.Engler@haw-hamburg.de

9.3 Heat and Awareness /Adaptation questionnaire

1. Willkommen bei der Umfrage der Anpassung von Gesundheitseinrichtungen an Hitze in Großstädten

Liebe Teilnehmerin, lieber Teilnehmer,
vielen Dank dafür, dass Sie sich einige Minuten Zeit nehmen um den folgenden Fragebogen auszufüllen.

Modellberechnungen prognostizieren, dass in den kommenden Dekaden die Häufigkeit und die Dauer von heißen Tagen und Hitzewellen in Deutschland weiter ansteigen werden (siehe Abb. 2). Diese Gegenheit wird in Großstädten zusätzlich durch den "städtischen Wärmeinsel Effekt" verstärkt (siehe Abb.1). Dieser Effekt wird durch die Temperaturdifferenz zwischen der wärmeren Stadt und ihrem kühleren Umland charakterisiert (z.B. Umland 30°C, Stadtkern 34°C) und erreicht ihr Maximum während sonnenscheinreicher und windschwacher Wetterlagen. Die Differenz kann in großen Städten sogar bis zu 10 Kelvin in der Nacht betragen.

Quelle: Abb.1) http://www.wetterdienst.de/maps/topics/waermeinsel_effekt.jpg und Abb. 2)
http://www.stadtentwicklung.berlin.de/umwelt/umweltatlas/s_abb/sa413_08_3_300.gif

Das Forschungs- und Transferzentrum "Applications of Life Sciences" (FTZ-ALS) der Hochschule für Angewandte Wissenschaft Hamburg möchte deshalb die Anpassungen und das Bewusstsein von Gesundheitseinrichtungen auf die Thematik "Hitze" erfassen.

Der Hintergrund dieser Befragung ist, dass es bislang noch wenige Daten über die Anpassung von Gesundheitseinrichtungen an Hitze gibt; deutschlandweit, wie auch in Ihrer Stadt. Diese Wissenslücke möchte das FTZ-ALS gerne füllen. Wir möchten Sie bitten den Fragebogen möglichst vollständig auszufüllen. Es erfolgt ausschließlich die Auswertung der Gesamtergebnisse, Einzelergebnisse werden nicht betrachtet. Daher ist es nicht möglich Rückschlüsse aus einer einzelnen Einrichtung zu ziehen.

Mit dem Beantworten der Fragen erklären Sie sich bereit, dass das FTZ-ALS Ihre Daten zur anonymen Auswertung verwenden darf.

Vielen Dank für Ihre Unterstützung.

Bei Fragen zur Umfrage wenden Sie sich gern an Herrn Engler: daniel.engler@haw-hamburg.de.

Daniel Engler

[redacted]

2. Allgemeine Informationen

Am Anfang ein paar Fragen zu Ihrer beruflichen Position und Ihrer Einrichtung...

1. Zu welcher Art von Einrichtung gehört diese Institution?

- ◯ Krankenhaus
- ◯ Pflegeeinrichtung, Seniorenwohnheim, Residenz
- ◯ Sonstige (bitte angeben)

2. In welchem Verwaltungsbezirk liegt diese Einrichtung?

3. Welche berufliche Position haben Sie innerhalb dieser Einrichtung?

- ◯ Leitung/ Management
- ◯ Qualitätsmanagement
- ◯ Wissenschaftliche Tätigkeiten
- ◯ Administration
- ◯ Arzt
- ◯ Pflegepersonal
- ◯ Sonstige berufliche Position (bitte angeben)

4. Wie viel Berufserfahrung haben Sie insgesamt in dieser Position?

- ◯ Weniger als zwei Jahre
- ◯ Zwei bis fünf Jahre
- ◯ Mehr als fünf Jahre

5. Wie lange arbeiten Sie schon in dieser Einrichtung?

- ◯ Weniger als zwei Jahre
- ◯ Zwei bis fünf Jahre
- ◯ Mehr als fünf Jahre

6. Wie viele Patienten/Bewohner Betten bzw. Plätze hat diese Einrichtung?

- ◯ 50 bis 150
- ◯ 151 bis 250
- ◯ 251 bis 500
- ◯ 500 bis 1000
- ◯ über 1000

3. Bewusstsein von Hitze

7. Sind Ihnen die allgemeinen gesundheitlichen Auswirkungen von Hitze in Ihrer Stadt bekannt?

- ◯ Ja
- ◯ Nein
- ◯ keine Angabe

8. In welchem Ausmaß kann der Faktor „Hitze" den Gesundheitszustand von Patienten/Bewohnern zusätzlich beeinträchtigen?

- ◯ Sehr
- ◯ Ein wenig
- ◯ Nicht besonders
- ◯ Gar nicht
- ◯ Nicht bekannt

9. Wurde die Anpassung an steigende Temperaturen in Ihrer Einrichtung schon einmal thematisiert?

- ◯ Ja
- ◯ Nein
- ◯ Nicht bekannt

10. Besteht ein erhöhter Betreuungs- bzw. Versorgungsbedarf der Patienten/Bewohner an heißen Tagen (mehr als 30 °C)?

- ◯ Sehr
- ◯ Ein wenig
- ◯ Gar nicht
- ◯ Nicht bekannt

11. Ist in der Einrichtung ein erhöhter Personalbedarf auf Grund eines erhöhten Betreuungs- bzw. Versorgungsbedarfs von Patienten/Bewohner an heißen Tagen (mehr als 30 °C) festzustellen?

- ◯ Sehr
- ◯ Ein wenig
- ◯ Gar nicht
- ◯ Nicht bekannt

12. Sind Sie aufgrund des Anstiegs der Häufigkeit und der Dauer von heißen Tagen im Jahr, um die Versorgungsqualität der Patienten/Bewohner besorgt?

- ◯ Sehr
- ◯ Ein wenig
- ◯ Gar nicht
- ◯ Nicht bekannt

13. Sind Sie daran interessiert, mehr über die Hitzeanpassung von Gesundheitseinrichtungen zu erfahren?

- ◯ Ja
- ◯ Nein
- ◯ keine Angabe

4. Information und Kommunikation

14. Erhalten Sie Hitzewarnungen durch eine Institution (z.B. Gesundheitsamt, deutscher Wetterdienst etc.)?

- ◯ Ja
- ◯ Nein
- ◯ Nicht bekannt

5. Information und Kommunikation

15. Auf welchem Kommunikationsweg erfolgt die Hitzewarnung?

- ◯ E-mail
- ◯ Telefonisch
- ◯ Medien, Presse
- ◯ Persönlicher Termin vor Ort
- ◯ Sonstiger Kommunikationsweg (bitte angeben)

16. Besitzt Ihre Einrichtungen ein „Newsletter-Abonnement" des Deutschen Wetterdienstes, welcher vor Hitze warnt?

- ◯ Ja
- ◯ Nein
- ◯ Nicht bekannt

17. Welcher Kommunikationsweg wäre am sinnvollsten für die Weiterleitung von Hitzewarnungen an Ihre Einrichtung?

- ◯ E-mail
- ◯ Telefonat
- ◯ Medien, Presse
- ◯ Persönlicher Termin vor Ort
- ◯ Sonstiger Kommunikationsweg (bitte angeben)

18. Glauben Sie, dass der Erhalt von Hitzevorhersagen oder -warnungen der Einrichtung hilft bzw. helfen würde, Schutzmaßnahmen anzuwenden?

- ◯ Ja
- ◯ Nein
- ◯ Nicht bekannt

6. Administration und Kompetenz

19. Gibt es in der Einrichtung eine Stelle bzw. berufliche Instanz, die sich mit der Thematik der „optimalen" klimatischen Anpassung der Einrichtung an höhere Temperaturen befasst?

- ◯ Ja
- ◯ Nein
- ◯ Nicht bekannt

7. Administration und Kompetenz

20. Welcher Fachbereich gewährleistet die „optimale klimatische Anpassung" der Einrichtung?

- ☐ Management der Einrichtung
- ☐ Gesundheitsexperte (Arzt, Pflege etc.)
- ☐ Sachbearbeitung (Administration)
- ☐ Qualitätsmanagement
- ☐ Facilitymanagement
- ☐ Sonstiger (bitte angeben)

21. Welcher Fachbereich würde sich eignen um die „optimale klimatische Anpassung" der Einrichtung zu gewährleisten?

- ◯ Management der Einrichtung
- ◯ Gesundheitsexperte (Arzt, Pflege etc.)
- ◯ Sachbearbeitung (Administration)
- ◯ Qualitätsmanagement
- ◯ Facilitymanagement

Sonstiges (bitte angeben)

8. Intervention

22. Gibt es in Ihrer Einrichtung einen Maßnahmenplan (z.B. Standardarbeitsanweisung für Mitarbeiter etc.) für besonders heiße Tage (mehr als 30 C) im Jahr?

- ◯ Ja
- ◯ Nein
- ◯ In Bearbeitung
- ◯ Nicht bekannt

Wenn ja, bitte kurze Beschreibung des Maßnahmenplans

9. Intervention

23. Besteht ein Bedarf für die Einrichtung, einen Maßnahmenplan zu erstellen, um zukünftig auf Hitzetage gut vorbereitet zu sein?

- ◯ Ja
- ◯ Nein
- ◯ Nicht bekannt

24. Gibt es Schulungen des Personals (oder ähnliche Maßnahmen) bezüglich Handlungsweisen für besonders heiße Tage (mehr als 30°C) im Jahr?

- ◯ Ja
- ◯ Nein
- ◯ Nicht bekannt

25. Gibt es Maßnahmen (z.B. Gratis Getränke) die ergriffen werden, um das Personal an heißen Tagen "leistungsfähig" zu halten?

- ◯ Ja
- ◯ Nein
- ◯ Nicht bekannt

wenn ja, bitte Maßnahmen beschreiben

26. Welche Maßnahmen werden ergriffen, um hitzebedingte Gefahren für die Patienten-/BewohnerInnen zu reduzieren?

	Ja, Fachpersonal handelt nach Standard	Ja, Fachpersonal handelt nach individueller Entscheidung	Nein	Nicht bekannt
Erhöhte Flüssigkeitszufuhr	○	○	○	○
Erhöhte Beobachtung der Flüssigkeitsbilanzierung	○	○	○	○
Mehrmalige kühlende Waschung am Tag	○	○	○	○
„Hitzeanfällige" Patienten/BewohnerInnen werden in kühleren Räumlichkeiten untergebracht	○	○	○	○
Das Fachpersonal achtet darauf, dass die Patienten/BewohnerInnen angepasst gekleidet sind	○	○	○	○
Schließen von Fensterläden am Tage und Lüften in der Nacht	○	○	○	○

weitere Maßnahmen (bitte angeben)

10. Bau und Einrichtung

27. Welche architektonischen Merkmale besitzt diese Einrichtung?

	Ja	Nein	Nicht bekannt
Jeder Patient/Bewohner hat ein Zimmer mit Klimaanlage	○	○	○
Patienten/Bewohner haben die Möglichkeit sich in klimatisierten Räumen der Einrichtung aufzuhalten	○	○	○
Fenster der Patienten-/Bewohnerzimmer können geöffnet werden	○	○	○
Helle Farbe der Dachoberfläche (reflektierend)	○	○	○
Bepflanzung des Daches (Green Roof)	○	○	○
Fassadenbegrünung	○	○	○
Garten/Parkanlage	○	○	○
Sonnenschutz-Einrichtungen der Patienten-/ Bewohnerzimmer (z.B. Markisen)	○	○	○
Thermometer bzw. Hygrometer in den Patienten-/Bewohnerzimmern	○	○	○
Südausrichtung von Patienten/Bewohnerzimmern	○	○	○
Wärmedämmung	○	○	○

Sonstige (bitte angeben)

28. Für zukünftige Hitzeereignisse wie beispielweise Hitzewellen (= über 3 Tage hinweg eine Höchsttemperatur von über 30°C) ist diese Einrichtung vorbereitet.

- ○ Sehr
- ○ Ein wenig
- ○ Gar nicht
- ○ Nicht bekannt

9.4 SPSS Syntax of the survey measurement

* Development of the Heat Awarness Index

```
RECODE Knowlege_of_Heatimpact (1=1) (2,3=0) INTO Knowlege_of_Heatimpact_Index.
RECODE Discussion_about_Heat (1=1) (2,3=0) INTO Discussion_about_Heat_Index.
RECODE Interest_of_Heatadaptation (1=1) (2,3=0)(1=3) (2=2) INTO
Interest_of_Heatadaptation_Index.
RECODE Receipt_of_Heatwarnings (1=1) (2,3=0) INTO Receipt_of_Heatwarnings_Index.
RECODE Professional_for_Heat (1=1) (2,3=0) INTO Professional_for_Heat_Index.
RECODE Education_about_Heat (1=1) (2,3=0) INTO Education_about_Heat_Index.
RECODE Heatcare_of_Medical_Staff (1=1) (2,3=0) INTO  Heatcare_of_Medical_Staff_Index.
RECODE Heat_Action_Plan (1,3=1)(2,4=0) INTO Heat_Action_Plan_Index.
EXECUTE.
DATASET ACTIVATE DataSet1.
COMPUTE HEAT_ARWARNESS_Index_Scale =Knowlege_of_Heatimpact_Index +
   Discussion_about_Heat_Index + Interest_of_Heatadaptation_Index +
Receipt_of_Heatwarnings_Index + Heat_Action_Plan_Index +
   Professional_for_Heat_Index + Heatcare_of_Medical_Staff_Index + Education_about_Heat_Index.
EXECUTE.
RECODE HEAT_ARWARNESS_Index_Scale (0 thru 1=1) (2 thru 3=2) (4 thru 5=3) (6 thru 7=4) (8 =5)
INTO Heat_Arwarness_INDEX.
EXECUTE.
FREQUENCIES HEAT_ARWARNESS_Index_Scale Heat_Arwarness_INDEX.
```

*Development of the Heat Adaptation Index

```
Recode Increased_Fluid_intake (1=2) (2=1)(3,4=0) into Increased_Fluid_intake_Index.
Recode Monitor_Fluid_Balancing (1=2) (2=1)(3,4=0) into Monitor_Fluid_Balancing_Index.
Recode Multiple_Cold_Washing (1=2) (2=1)(3,4=0) into Multiple_Cold_Washing_Index.
RECODE Transfer_into_Cooler_Surroundings (1=2) (2=1)(3,4=0) into
Transfer_into_Cooler_Surroundings_Index.
RECODE  Appropriate_clothing_Patients (1=2) (2=1)(3,4=0) into
Appropriate_clothing_Patients_Index.
Recode Pull_down_Shutters (1=2) (2=1)(3,4=0) into Pull_down_Shutters_Index.
Recode Every_Room_Airconditioning (1=10) (2,3=0) into Every_Room_Airconditioning_Index.
```

```
Recode Possibility_Stay_Aircoditioned_Room (1=5) (2,3=0) into
Possibility_Stay_Aircoditioned_Room_Index.
Recode Possibilty_Open_Window (1=3) (2,3=0)  into Possibilty_Open_Window_Index.
RECODE Light_Colour_Roof_Surfaces (1=5) (2,3=0) into Light_Colour_Roof_Surfaces_Index.
RECODE Planting_Roof (1=5) (2,3=0) into Planting_Roof_Index.
Recode  Facade_Greening (1=5) (2,3=0) into Facade_Greening_Index.
Recode Garden_Park (1=5) (2,3=0) into Garden_Park_Index.
Recode Sun_Protection_Devise (1=3) (2,3=0) into Sun_Protection_Devise_Index.
RECODE Hygrometer (1=2) (2,3=0) into Hygrometer_Index.
Recode South_Alignment_Patientrooms (1=5) (2,3=0) into South_Alignment_Patientrooms_Index.
Recode Heat_isolation (1=5) (2,3=0) into Heat_isolation_Index.
COMPUTE HEAT_Adaptation_Index_Scale=Increased_Fluid_intake_Index +
Monitor_Fluid_Balancing_Index +
   Multiple_Cold_Washing_Index + Transfer_into_Cooler_Surroundings_Index +
Appropriate_clothing_Patients_Index +
   Pull_down_Shutters_Index + Every_Room_Airconditioning_Index +
Possibility_Stay_Aircoditioned_Room_Index +
   Possibilty_Open_Window_Index + Light_Colour_Roof_Surfaces_Index + Planting_Roof_Index +
Facade_Greening_Index + Garden_Park_Index
   + Sun_Protection_Devise_Index + Hygrometer + South_Alignment_Patientrooms_Index +
Heat_isolation_Index.
RECODE HEAT_Adaptation_Index_Scale (0 thru 13=1) (14 thru 26=2) (27 thru 39=3) (40 thru 52 =4)
(53 thru
   65=5) INTO Heat_Adaptation_INDEX.
EXECUTE.
FREQUENCIES HEAT_Adaptation_Index_Scale Heat_Adaptation_INDEX.
```

<u>* Heat Adapatation Index Reliability Test</u>

```
RELIABILITY
  /VARIABLES=Increased_Fluid_intake Monitor_Fluid_Balancing Multiple_Cold_Washing Hygrometer
   Transfer_into_Cooler_Surroundings Sun_Protection_Devise Facade_Greening
   Appropriate_clothing_Patients Pull_down_Shutters Planting_Roof Light_Colour_Roof_Surfaces
   Every_Room_Airconditioning Possibilty_Open_Window
  /SCALE('ALL VARIABLES') ALL
```

```
 /MODEL=ALPHA
 /STATISTICS=DESCRIPTIVE SCALE CORR
 /SUMMARY=TOTAL MEANS VARIANCE.
```

*Heat Awarness Index Reliability_Test

```
RELIABILITY
 /VARIABLES=Knowlege_of_Heatimpact Discussion_about_Heat Interest_of_Heatadaptation
  Receipt_of_Heatwarnings Professional_for_Heat Heat_Action_Plan Education_about_Heat
  Heatcare_of_Medical_Staff
 /SCALE('ALL VARIABLES') ALL
 /MODEL=ALPHA
 /STATISTICS=DESCRIPTIVE SCALE CORR
 /SUMMARY=TOTAL MEANS VARIANCE.
```

*Correlation von Awarness gegen Adapation

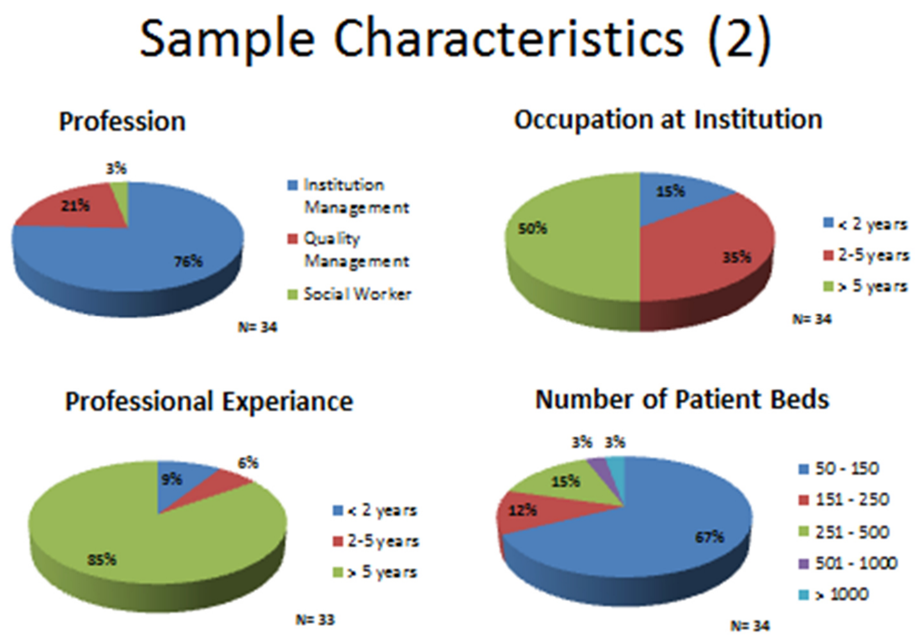
```
CORRELATIONS
 /VARIABLES=HEAT_ARWARNESS_Index_Scale HEAT_Adaptation_Index_Scale
 /PRINT=TWOTAIL NOSIG
 /STATISTICS DESCRIPTIVES XPROD
 /MISSING=PAIRWISE.
NONPAR CORR
 /VARIABLES=HEAT_ARWARNESS_Index_Scale HEAT_Adaptation_Index_Scale
 /PRINT=SPEARMAN TWOTAIL NOSIG
 /MISSING=PAIRWISE.
```

*Linear Regression Awareness vs Adaptation

```
REGRESSION
 /DESCRIPTIVES MEAN STDDEV CORR SIG N
 /MISSING LISTWISE
 /STATISTICS COEFF OUTS CI(95) R ANOVA
 /CRITERIA=PIN(.05) POUT(.10)
 /NOORIGIN
 /DEPENDENT HEAT_Adaptation_Index_Scale
```

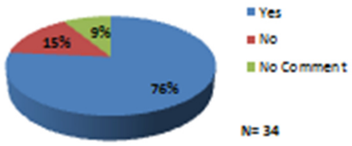
```
/METHOD=ENTER HEAT_ARWARNESS_Index_Scale
/SCATTERPLOT=(*ZRESID ,*ZPRED)
/RESIDUALS HISTOGRAM(ZRESID) NORMPROB(ZRESID)
/SAVE PRED ZPRED ADJPRED.
```

9.5 Supplement of the Heat awareness/adaptation questionnaire



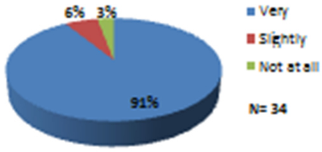
Awareness of Heat risks (1)

Are you aware of the heat-induced general health impact in your city?



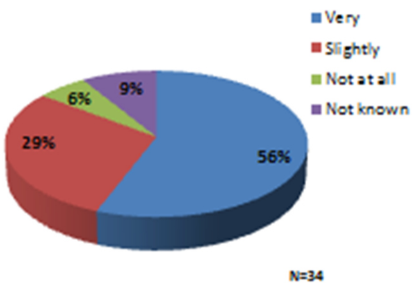
Have you ever discussed about heat adaptation at your Institution because of the increased temperatures per year?

To what extent the factor "heat" can additionally influence the well being of patients/residents?

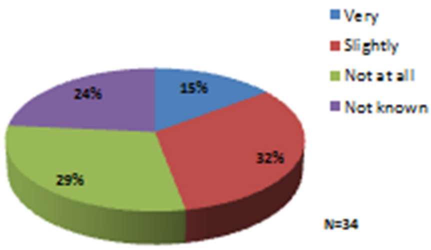


Awareness of Heat Risks (2)

An increase in patient care can be seen during hot days (> 30°C)

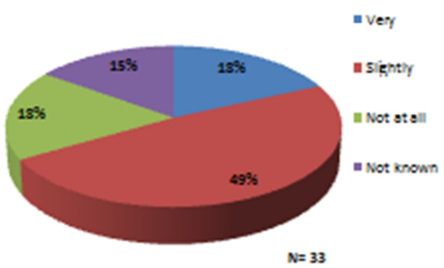


An increased demand of medical staff based on the increase in patient care during hot days (>30°C)

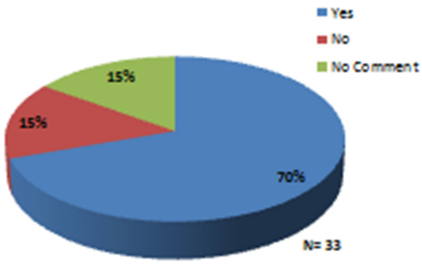


Awareness of Heat Risks (3)

Are you concerned about the quality of care regarding inrease of frequancy and duration of hot days in the future?

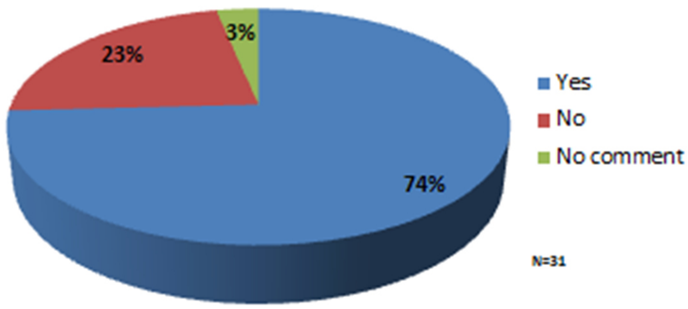


Are you interrested to get more information about heat adaptation of health care providers?

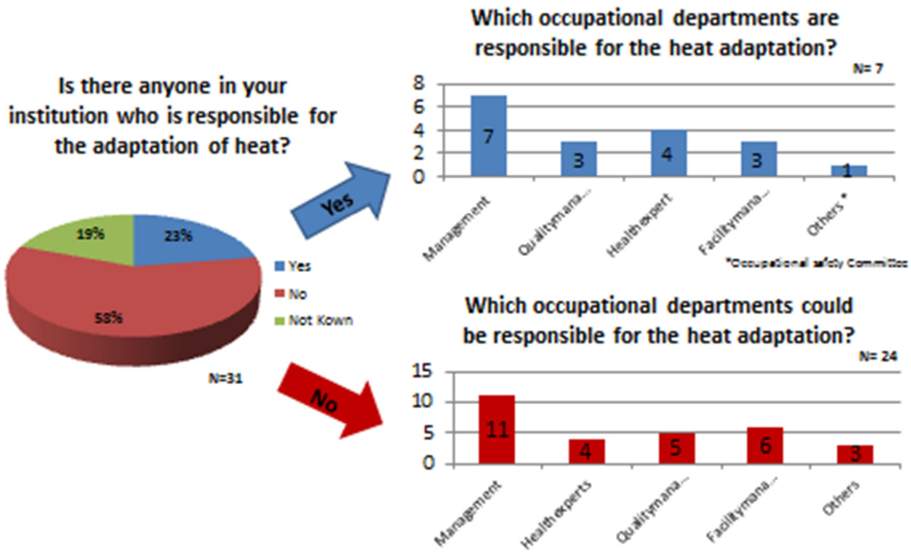


Information & Communication (2)

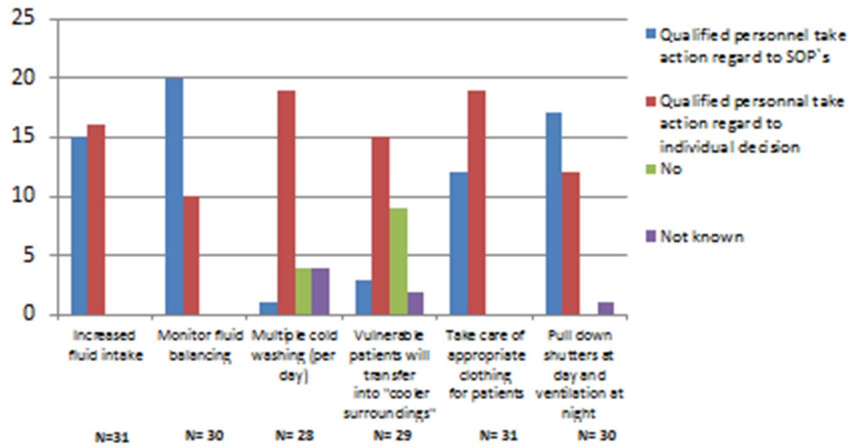
Believe that, received heat warnings help to implement heat protective interventions



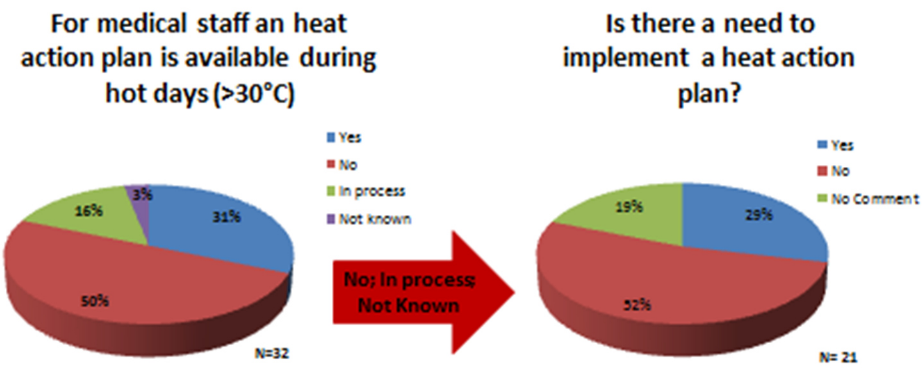
Administration & Competences



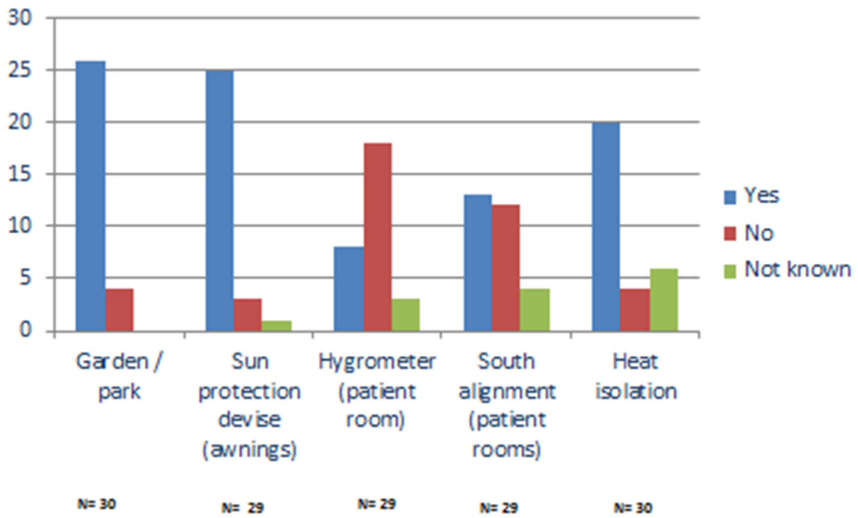
Modalities of Heat Intervention (3)



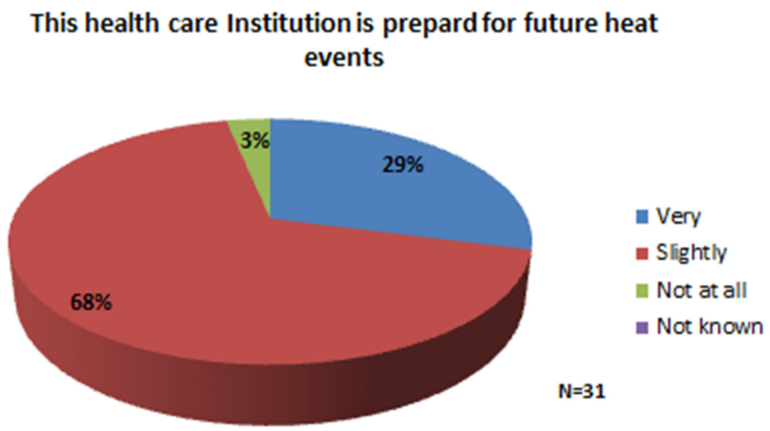
Modalities of Heat Intervention (1)



Building Structure & Equipment (2)



Estimation of Heat-Preparedness



10 Statutory Declaration

I declare that I have developed and written the enclosed Master Thesis completely by myself, and have not used sources or means without declaration in the text. Any thoughts from others or literal quotations are clearly marked. The Master Thesis was not used in the same or in a similar version to achieve an academic grading or is being published elsewhere.

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Date, Signiture