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Climate warming and health adaptation in Finland

Juhani Hassi and Mika Rytkönen

FINADAPT Working Paper 7

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FINADAPT WORKING PAPER 7

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Preface

The Intergovernmental Panel on Climate Change (IPCC) defines adaptation as "Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities"[1]. The IPCC lists two reasons why adaptation is important in the climate change issue. First, an understanding of expected adaptation is fundamental in evaluating the costs or risks of climate change. Second, adaptation is a key response option or strategy, along with mitigation. Even with reductions in greenhouse gas emissions, some climate change is regarded as inevitable, and it will be necessary to develop planned adaptation strategies to deal with the associated risks as a complement to mitigation actions.

In Finland, there has been substantial progress during the past decade in investigating the potential impacts of climate change on natural and human systems. In contrast, there has been much less attention paid to adaptation. This was recognised by the Finnish Parliament as early as 2001, when it recommended that a separate programme for adaptation to climate change be initiated. As a result, a task force co-ordinated by the Ministry of Agriculture and Forestry completed Finland's first National Strategy for Adaptation to Climate Change in 2005.[2]

At about the same time as the Strategy document was being drafted, a research consortium named FINADAPT also began its work. The goal of the consortium, involving 11 partner institutions co-ordinated by the Finnish Environment Institute, was to undertake an in-depth study of the capacity of the Finnish environment and society to adapt to the potential impacts of climate change. FINADAPT was funded for the period 2004-2005 as part of the Finnish Environmental Cluster Research Programme, co-ordinated by the Ministry of the Environment. It comprised 14 work packages (WP) covering: 1) co-ordination, 2) climate data and scenarios, 3) biodiversity, 4) forests, 5) agriculture, 6) water resources, 7) human health, 8) the built environment, 9) transport, 10) energy infrastructure, 11) tourism and recreation, 12) economic assessment, 13) urban planning, and 14) a stakeholder questionnaire. The primary objective of FINADAPT was to produce a scoping report based on literature reviews, interactions with stakeholders, seminars, and targeted research.

This report presents the findings of work package 7, describing the implications of climate change for human health adaptation. It represents one of the first studies to have been conducted on this theme in Finland.

Timothy Carter, Consortium Leader
Helsinki, December 2005

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[1] IPCC, 2001. *Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change* [McCarthy, J.J., O.F. Canziani, N.A. Leary, D.J. Dokken, and K.S. White (eds)]. Cambridge University Press, Cambridge and New York, p. 982.

[2] MMM, 2005. *Ilmastomuutoksen kansallinen sopeutumisstrategia* (Finland's National Strategy for Adaptation to Climate Change) [Marttila, V., Granholm, H., Laanikari, J., Yrjölä, T., Aalto, A., Heikinheimo, P., Honkatuki, J., Järvinen, H., Liski, J., Merivirta, R. and Paunio, M. (eds)], Ministry of Agriculture and Forestry, Helsinki (available in Finnish, 276 pp. and English, 280 pp.) http://www.mmm.fi/sopeutumisstrategia/

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CLIMATE WARMING AND HEALTH ADAPTATION IN FINLAND

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Executive Summary

Climate change will cause increased heat-related mortality and morbidity in Finland. Extremes of both heat and cold can cause potentially fatal illnesses. Increased flooding could lead to associated health impacts, increase the risks of emerging infectious diseases and change in the transmission intensity, geographical and seasonal range of certain vector and water-borne diseases. Some of the health impacts of climate change would be beneficial. However, most of the health impacts of climate change are likely to be adverse. Certain groups will be particularly vulnerable to disease and injury.

The extent to which human health is affected depends on: the exposures of populations to climate change and its environmental consequences, the sensitivity of the population to the exposure, and the adaptive capacity of the systems, society and populations. Public health infrastructure has been mentioned as the “most important, cost-effective and urgently needed” adaptation strategy. Furthermore, adapting to climate change will require education, awareness-raising, and institutions and an environment that enables people to receive and use information. Adaptation takes place in several levels and therefore the roles of individuals, communities, nations, institutions and private sector has to be considered in planning of adaptation strategies.

There is a quite high confidence that a prediction of climate warming until 2050 will not pose particular new risks for the population of Finland. Heat-related mortality and morbidity will be increased slightly; respectively wintertime mortality and morbidity will decrease under a warming environmental temperature. Future climate scenarios include increasing number and severity of extreme weather events occurring in Finland. Short-term extreme weather events, both extensive heat and cold, will probably cause most of additional burden of climate induced adverse health direct outcomes in Finland. In increased risks are elderly and children, and those with poor health. A risk of some infectious diseases may increase. Infectious diseases need improved awareness and surveillance. Thinner and shorter endurance of ice-cover of waterways will increase the risk of accidents. The changes in vegetation may increase the atmospheric pollen may increase the burden to many allergic individuals.

The adaptive capacity of Finnish society is fairly good as we are able to maintain the public health infrastructure and achieve sustainable political and economical development. Ageing population together with threats posed by climate has to be underlined. Although acclimatization takes place in a relatively short period of time, the behavioral changes are required as part of beneficial adjustment. Urbanization may decrease the adaptive capacity as urban population is considered to cope less well with harsh climatic conditions as their counterparts in rural areas do. This means threats especially for teenagers and old people.

Spontaneous adjustments to extreme heat might not compensate fully for effects of future heat waves in Finland. The future adaptive capacity is also a function of population health status and pre-existing disease burdens.

Climatic change will be one among many exacerbating factors. Despite the fact that our understanding of the links between climate, climate change and human health have increased considerably, there are still many gaps in knowledge about likely future patterns of exposure to climatic-environmental changes, and their adverse health effects. Future research in Finland should aim to increase epidemiological knowledge on both direct and indirect health impacts of climate change, of climate variability and of extreme weather events, should produce spatially defined and subpopulation specific information on the climate induced health risks and should finally offer recommendations to be utilized in the health care sector and by decision-makers. Awareness building based on the scientific facts of the climate-health relationship is probably the best alternative to tackle climate induced health risks. The adaptation measures identified in any climate change health impact assessment are of importance regardless of future climate change. In other words, the work to develop adaptation strategies should be considered beneficial, even if climate change scenarios and their projected health impacts were to prove inaccurate.

1. Introduction

The Finnish research reports concerning climate change and health are very limited. Thus, a relatively large number of international scientific reports was utilized for the processing this FINADAPT scoping report on the health and adaptation issues under warming climate in Finland. However, the number of original papers and reviews were also produced in the framework of FINADAPT project. The most useful might be a special issue on "Climate change and human health" which was published in the International Journal of Circumpolar Health (IJCH 2005, 64, 5) in December 2005, and the special issue "Cold and Health" which was published earlier this year in the Duodecim (Duodecim 2005, 4, 417-464). We also organized an expert seminar on "Climate and Extreme Weather Events and Their Adverse Effects on Human Health: The Research Needs of the Future" in November 2004. The seminar gathered health and climate researchers, environmental scientists and health policy makers, and discussed crucial aspects of the effects of climate on human health, and was aimed to identify major gaps in knowledge and needs for future research. Unfortunately, we failed to get any Finnish experts of infection diseases to the seminar, and therefore the evaluation of this field remained less voluminous than we hoped. This health report uses climate change projections/scenarios presented in the meteorological part of the main report. Some of the assumptions presented here concerning future extreme events and their health consequences were based on the report "Extreme Weather Events and Public Health Responss" which was published by the European Office of WHO (Kirch et al. 2005).

Human health is the result of the interaction of genetic, nutritional, socio-cultural, economic, physical infrastructure and ecosystem factors (Figure 1). All of the individual, social, cultural and socio-economic factors are influenced by the environment they are embedded in and by changes in this environment (Curtis et al. 2005).

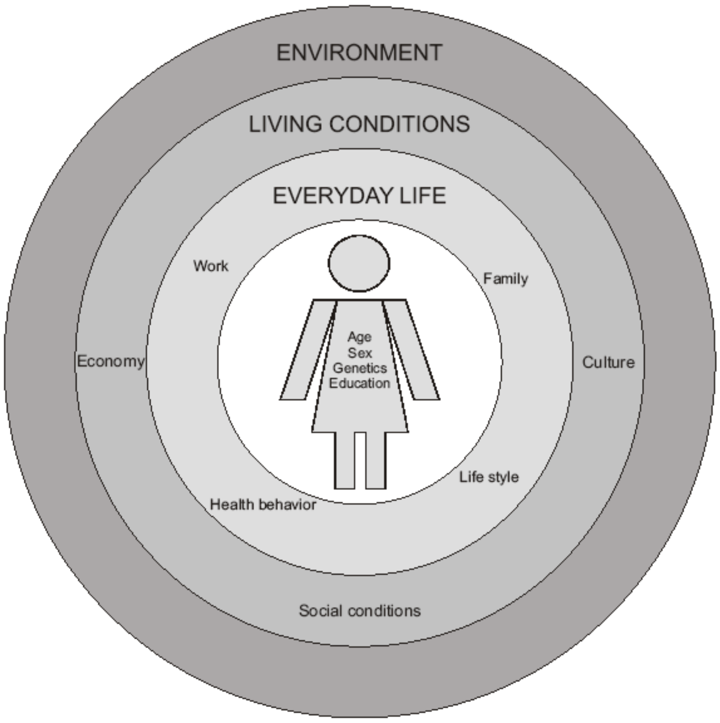

Figure 1 A model of factors influencing health (Curtis et al. 2005).

In the circumpolar north, as in all other regions, climate is a major, constantly changing component of the environment. The mechanisms of climate impacts on health are divided into two broad categories: First, direct impacts, such as those directly caused by temperature, or ultraviolet light; secondly, indirect impact mechanisms, such as climate induced changes in wildlife and the diseases they share with humans (zoonotic disease). These topics were felt to represent impact areas which currently are showing some degree of response to climate change, with a potential, or established, impact on human health (Berner 2005). Many of health impacts are expected to be complex of indirect impacts (e.g. changes in transport and bioavailability of contaminants and increased human exposure and resulting health impacts, changes in environmental conditions which provide the foundation for lifestyles and well-being resulting in impacts to social and mental health (Furgal 2005). The impact of technology has unintended climate consequences, such as the destruction of atmospheric ozone by chlorofluorocarbon aerosol propellants and refrigerant compounds. For these reasons, the future discussion of health impact of climate change must deal with mechanisms, rather than attempting to predict health status in a given set of climate conditions, at some time in the future (Berner 2005).

Seasonal changes in human health are remarkable and have been recognized for more than 2000 years (Ballester et al. 2003). Mortality generally increases at both high and low temperatures above and below an optimum thermal threshold (Curriero et al. 2002). Mortality increases in both sides of this thermal threshold forming a U- or V-shaped curve. Optimum thermal thresholds for minimum mortality vary between populations and geographical areas (Figure 2). In the Mediterranean countries this threshold varies between +22 - +25 °C (The Eurowinter Group 1997). In Finland, mortality peaks in autumn and reaches its highest point during December, and decreases slowly to a minimum in August. The optimum thermal threshold for minimum mortality is + 14 °C in Finland (Näyhä 2005) (Figure 3). The thermal threshold for the mortality minimum is lower in the north than in the south. For instance, the minimum incidence of fatal AMI attacks in the Kuopio area (63°N) occurs at 5.4°C, while the minimum in the Helsinki area (60°N) is at 11.8°C, respectively.

In addition, seasonal variations in climatically extreme weather events, including extensive cold and heat, can have profound effects on human health. Populations in warmer regions tend to be sensitive to low temperatures, and populations in colder climates are sensitive to heat (The Eurowinter Group 1997; Kalkstein and Greene 1997; Patz and Kovats 2002). Mortality increases clearly in Finland when daily average temperature remains above +20 °C for 1-2 weeks. It is estimated that the heat wave in 1972 caused 800 premature deaths in Finland (Näyhä 1981). The heat waves in 1973, 1978, 1988, 1995 and 1997 also caused some extra deaths in Finland. The effect of heat on mortality has diminished during the recent decades in Finland. Here, the heat-related mortality represents only 0.2-0.4 % of annual deaths, while it was 1.5–2.3 % during the 1970s (Näyhä 2005). During the last three decades heat waves have caused a large number of extra deaths in Europe, for example, in France 1975, in Greece 1987, in Belgium 1994, in Wales and England 1995. The heat waves of 1980, 1983, 1988 and 1995 were estimated to be directly responsible for thousands of deaths across the United States (Katsouyanni et al. 1988; 1995; Sartor et al. 1995; Semenza et al. 1996; Rooney et al. 1998; Bouchama 2004). Most recently, during summer 2003, the early onset of hot weather, unusually high temperatures, and prolonged heat-stress conditions caused extreme peaks in mortality throughout Europe (Bosch 2003; Grynszpan 2003; Bouchama 2004; CDC 2004; Franklin 2004). During a nine-day period of extensive heat in August 2003, 14 800 extra deaths were certified in France alone (Dhainaut et al. 2004; Ledrans et al. 2004).

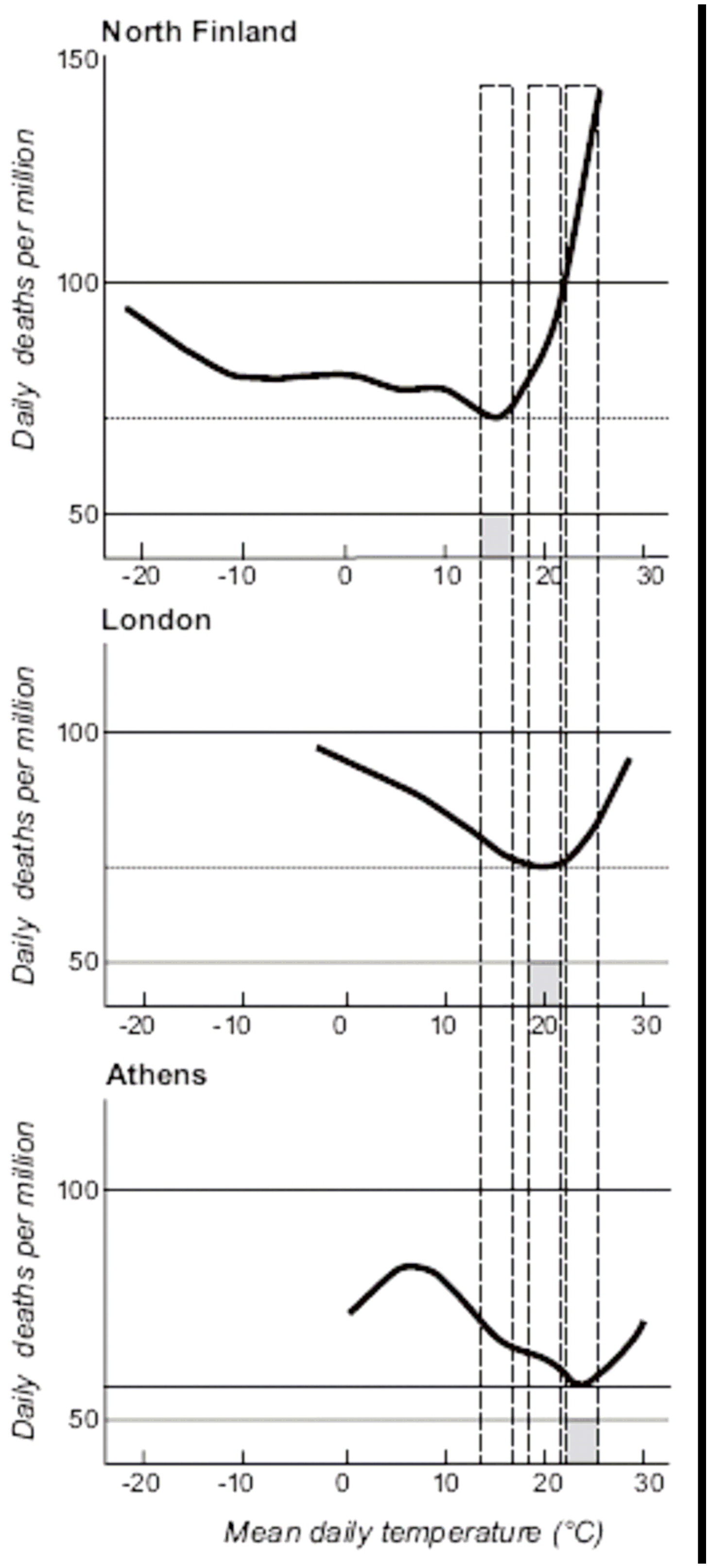

Figure 2 Daily mortality of people aged 65-74 in relation to mean daily temperatures in regions with the coldest, median, and warmest summer temperatures (May to August). The gray squares indicate the 3°C band of minimum mortality for the region (calculated at 0.1°C intervals) and the horizontal lines show mortality in this band. (Figure modified from Keatinge et al. 2000. Heat related mortality in warm and cold regions of Europe: observational study.)

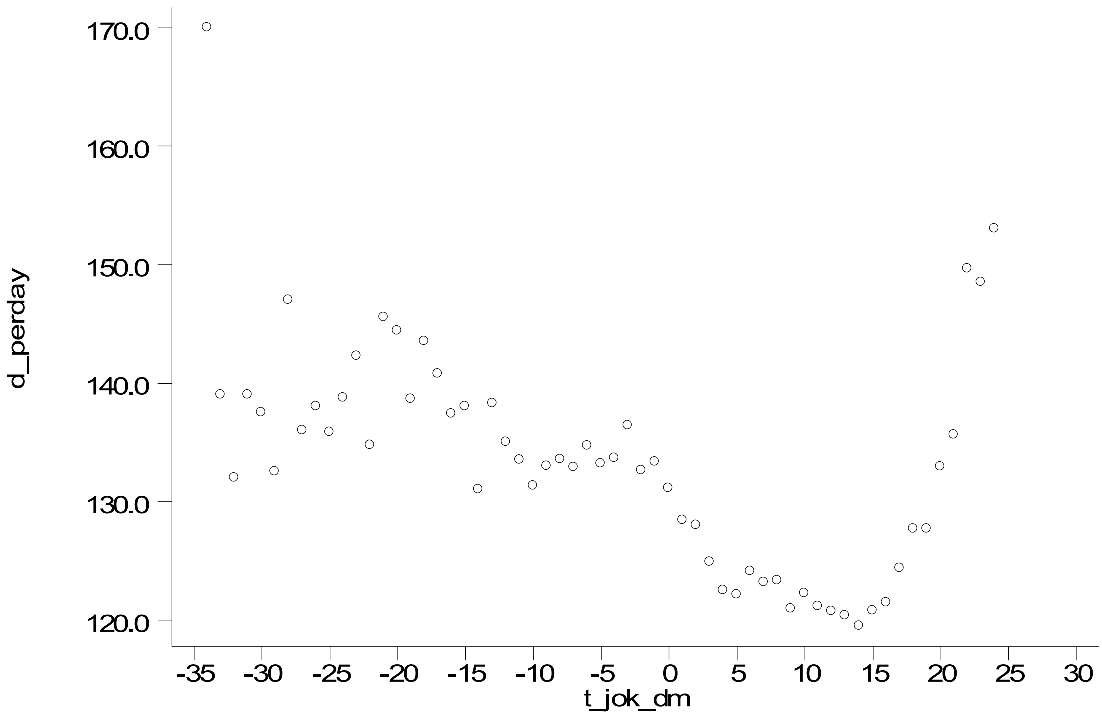

Figure 3 Daily mortality in Finland (d–perday) in relation to mean daily temperatures at Jokioinen (d_jok_dm) during 1971-1997. Although the daily temperature data are not representative of the whole country, the figure successfully shows the mortality minimum and an increase on both sides of this thermal threshold (Mortality Data: Statistics Finland; Climatic data: Finnish Meteorological Institute).

Heat stress aggravates the symptoms of coronary artery disease, diabetes and respiratory diseases and increases the risk of death (Ellis and Nelson 1978; Smoyer-Tomic and Rainham 2001). Heat disorders encountered during heat stress include heat exhaustion (accompanied by headache, nausea, fainting, etc.) and, worse, heat stroke (where the body's thermoregulatory system fails and core temperatures rise to undesirable levels) (CDC 1997; Watson et al. 2005). While heat exhaustion responds rapidly to prompt treatment, heat stroke represents a medical emergency. Populations at particularly high risk include the elderly, those on certain medications, and those with pre-existing illnesses, particularly if they reside in cities (Semenza et al. 1996; Smoyer 1998; Smoyer et al. 2000). During the 2003 heat wave approximately 20 000 elderly citizens died in the city of Paris and the industrial towns of the northern Italy. The timing of the event and its duration have also been shown to be important, with heat waves occurring early in the season having higher associated mortality than those later in the season. In addition, prolonged hot conditions are more stressful to human health than isolated hot days (Kalkstein 1993; Kalkstein and Smoyer 1993).

Excess winter mortality is a well-reported phenomenon throughout the world, and most countries suffer from 5% to 30% excess winter mortality (Kunst et al. 1993; Keatinge and Donaldson 1995; Näyhä and Hassi 1995; The Eurowinter Group 1997; Eng and Mercer 1998; Kloner et al. 1999; Gemmell et al. 2000; Hassi et al. 2000; Keatinge et al. 2000a; Keatinge et al. 2000b; Näyhä 2000, 2002; Healy 2003; Mercer 2003). Half of the excess winter mortality is due to cerebrovascular diseases and ischemic heart disease and the other half due to respiratory disorders. Some 3500 extra deaths occur during the winter seasons in Finland, of which 900 are certified as being due to coronary heart disease (CHD) and 500 to stroke. Deaths by cold weather are quantified by epidemiological studies (Doyle 1998). Figures based on monthly, rather than daily, statistics underestimate problems related to cold climate

(Keatinge 2002). Most of the seasonal fluctuation seems to be related to cold, with smaller components attributable to influenza A and other risk factors (Wilkinson et al. 2004). The mechanisms are still unknown for the excess winter mortality, but mechanisms leading to the possible influence of environmental temperature on human health are most likely multifactorial. Sympathetic tone, blood pressure, myocardial oxygen consumption, red blood cell and platelet count, plasma beta-thromboglobulin, platelet factor 4 and plasma fibrinogen have been shown to increase, and antithrombin III to decrease, with colder weather (Keatinge et al. 1984; Kawahara et al. 1989; Woodhouse et al. 1993; Näyhä 2002). Respiratory and other infections, viral and bacterial, which mostly occur in winter, may trigger attacks of coronary heart disease or stroke, as they affect blood coagulation factors, cause damage to vessel walls and may promote atherosclerosis.

Some recent studies have reported other health problems than mortality related to cold weather (Hassi 2005). Cold-related performance limitations, illnesses and injuries are very common during every winter in Finland (Hassi and Mäkinen 2000; Juopperi et al. 2002; Kotaniemi et al. 2002; Lehmuskallio et al. 2002; Ervasti et al. 2004; Hassi et al. 2005a; Hassi et al. 2005b; Rytkönen and Hassi 2005; Rytkönen et al. 2005) causing significant restrictions to the working capacity of individuals and high economic losses to society as a whole. Cold climate induced adverse health effects are also associated with an increased consultation load for the health care system. Cold related illnesses are diseases either caused by cold or are affected by cold exposure. They can be recognized in many types of symptoms of diseases and illnesses such as cardiovascular diseases, respiratory diseases, diseases in peripheral circulation, musculoskeletal diseases and skin diseases. Symptoms induced by cold temperatures are diverse and they originate from various organs of the human body (Hassi and Rintamäki 2002). Approximately 30% of Finns suffer from chronic diseases or conditions that are known to be sensitive to cold exposure. There are great individual differences in the ability to cope with stressful cold environments. In general, small children, the elderly, individuals with health problems and those with poor physical fitness or those who are poorly prepared have a higher risk of deleterious effects of low temperatures (The Eurowinter Group 1997; Donaldson et al. 1998; Stocks et al. 2004).

Global warming is likely to bring not only warmer temperatures on average ranging from 1.7 to 4.9°C by the year 2100 (IPCC 2001), but greater frequency of extreme weather events, including cold days . The many health effects posed by climate change will arrive through numerous complex and unpredictable pathways and, therefore has a range of impacts on human health (WHO 2003; Haines and Patz 2004; Patz 2004; Patz et al. 2005). There is a consensus that climate change will cause increased heat-related mortality and morbidity. Extremes of both heat and cold can cause potentially fatal illnesses, increase the risks of flood and air pollution associated health impacts, increase the risks of emerging infectious diseases and change in the transmission intensity, geographical and seasonal range of certain vector and water-borne diseases (Menne and Campbell 2005; Watson et al. 2005). Some of the health impacts of climate change would be beneficial. For example, milder winters would reduce the seasonal wintertime peak in deaths that occurs in temperate countries. However, most scientists consider that most of the health impacts of climate change would be adverse. For each potential impact of climate change, certain groups will be particularly vulnerable to disease and injury. The vulnerability of a population depends on factors such as population density, level of economic development, local environmental conditions, pre-existing health status, and the quality and availability of public health care (Woodward et al. 2000). The most recent review on the impacts of regional climate change on human health (Patz et al. 2005) does not extend the discussion to the sparsely populated northern areas. We need more information about the impacts of climate change on the northern populations, who have adapted to cold climate and will face health impacts of climate warming in totally different circumstances than populations in moderate or warm climatic regions.

The emerging climate change-related health consequences in Finland require discussion and analyses of how we can respond, both now and in the future. In theory, responses can be categorized into the following: (a) dealing with the effects, (b) identifying and dealing with the causes, (c) establishing processes to sustain and adapt both these types of efforts over the long periods required for managing climate change.

2. Project deliverables

2.1. Publications of the project

Hassi, J. (2005) Cold Extremes and Impacts on Health. Teoksessa: Extreme Weather Events and Public Health Responses. Toim.: Kirch, W., Menne, B., & Bertollini, R. Springer-Verlag, Heidelberg.

Special issue ”CLIMATE CHANGE AND HUMAN HEALTH” in International Journal of Circumpolar Health 2005, 64:434-533

Special issue “Cold climate and health” in Duodecim 4/2005 included 8 articles

Hassi, J. Pääkirjoitus: Kylmä vaikuttaa monin tavoin terveyteemme. Duodecim 2005; 121: 417-418

Rytkönen, M., Raatikka, V-P., Näyhä, S., Hassi, J. Kylmälle altistuminen ja kylmäoireet. Duodecim 2005; 121: 419-423

Näyhä, S. Kylmä, kuuma ja kuolleisuus. Duodecim 2005; 121: 433-439

Hassi J, Lehmuskallio E, Junila J, Rytkönen M. Paleltumat ja muut ihoon kohdistuvat kylmähaitat. Duodecim 2005; 121:454-461

Hassi J, Rytkönen M, Kotaniemi J, Rintamäki H (2005) Impacts of cold climate on human heat balance, performance and health in circumpolar areas. International Journal of Circumpolar Health 2005, 64;459-467

Hassi J. Ckunate change: a challence to adapt 2005, 64,434

Mäkinen T, Raatikka V-P, Rytkönen M, Jokelainen J, Rintamäki H, Ruuhela R, Näyhä S, Hassi J (2005) Factors affecting out-door exposure in winter: population based study. MANUSCRIPT submitted to Biometeorology.

Rytkönen M, Hassi J (2005) Prevalence of cold-induced symptoms in Finland. Biometeorology. MANUSCRIPT submitted to Biometeorology.

2.2. Networks and co-operation

- COST 730 Action (UTCI- Universal Thermal Climate Index)
- WHO (Extreme Weather Events and Their Health Impacts in Europe)
- Health initiative for International Polar Year 2007-2008 –research program
- Research co-operation established with National Public Health Institute and Finnish Meteorological Institute
- Planning the Circumpolar health and wellbeing –research program (Thule Institute, University of Oulu)

2.3. Conference proceedings

Rytkönen M & Hassi J (2005) Prevalence of cold-induced symptoms in Finland. 17th International Congress of Biometeorology ICB 2005, 5.-9.9.2005, Garmisch-Partenkirchen, Germany.

Ruuhela R, Venäläinen A, 1 Pirinen P, Havulinna A, Karvonen M, Rytkönen M, Hassi J. The synoptic weather situation on days of high incidence of acute myocardial infarction. 17th International Congress of Biometeorology ICB 2005, 5.-9.9.2005, Garmisch-Partenkirchen, Germany.

Havulinna A, Pirinen P, Ruuhela R, Venäläinen A, Karvonen M, Rytkönen M, Hassi J (2004) The effect of climatic factors on the onset of acute myocardial infarction in Finland. Kastelli Symposium, 19.-20.11.2004. Kastellin tutkimuskeskus, Oulu.

2.4. Seminars and workshops

- Expert Seminar on "Climate and Extreme Weather Events and Their Adverse Effects on Human Health: The Research Needs of the Future". November 30th 2004, 8:30 a.m. – 16:30 p.m. University of Oulu

The seminar gathered health and climate researchers, environmental scientists and health policy makers, and discussed crucial aspects of the effects of climate on human health, and was aimed to identify major gaps in knowledge and needs for future research. The purpose of the seminar was to outline current knowledge about the risks posed by climate for human health, and to identify the factors that determine the vulnerability of human systems to extreme weather events, climate variability and change, and how vulnerability can be reduced.

As a summary: climate change can affect human health directly (e.g., impacts of thermal stress, deaths and injuries) and indirectly through changes in our environment (water quality, food availability and quality, water-borne pathogens etc.). The actual health impacts will be strongly influenced by local environmental conditions and socio-economic circumstances, and by the range of social, institutional, technological and behavioural adaptations taken to reduce the full range of threats to human health. Despite the fact that our understanding of the links between climate, climate change and human health has increased considerably, there are still many gaps in knowledge about likely future patterns of exposure to climatic-environmental changes, and its adverse health effects.

Acute exposures to the thermal stressors have several adverse effects on human physiological and psychological performance and health. The detailed mechanisms of the development of climatic adaptation and especially its functional significance are not known and also need for further research. Furthermore, the health care sector will face new challenges in the future because of changing environment and climate. Because of the potentially profound long-term health impacts of climate change, research on health care sector should be emphasized to better understand the health effects of climate change and the role of the health sector in addressing this issue.

The funding resources for the research on climate change and health in Finland have been limited. The Ministry of Health and Social Affairs funds research on climate change and its health impacts (for example, mortality studies) through WHO. However, there is arising awareness of the national funding needs, but they are not available yet. Multidisciplinary research program International Polar Year IPY will put the stress on the Finnish funding institutions, e.g. Academy of Finland.

The final discussion of the seminar especially underlined the importance of national and international collaboration (research, data integration, methodology development, awareness building) and increased needs for multidisciplinary research programs targeted on a complex climate-health relationships and adaptation questions. The meeting also stated that the lack of the Finnish knowledge in many of key issues of the topic. A special issue in the International Journal of Circumpolar Health reflects to this need.

3. Scenarios and assumptions

The mean global surface temperature has warmed significantly over the past 100 years. Historical data support the theory that an altered hydrologic cycle will accompany warming of the earth's surface (Bernard and Ebi 2001). There is a scientific consensus that global warming is particularly evident in the Circumpolar North. Climate change during the 21st century is predicted to be rapid and large. A special feature of this change is the variability of future climate and the occurrence of extreme conditions. These include anomalously high and low temperatures, more intense precipitation events and possible increase in peak wind speeds. According to FINADAPT climate scenarios (see Ruosteenoja et al.; Carter et al. 2005), at the end of this century climate in Finland changes as follows:

- Mean temperatures are projected to increase by ~4°C in summer and more than 6°C in winter
- Winter precipitation increases by more than 20%
- Snow cover is reduced markedly
- Summers may be slightly sunnier than at present
- Hot summer days will be about four times more common than today
- The number of frost days decrease
- Frost-free period in summer will lengthen by 2 months or even more.

Current trends in demography and urbanization show that only few urban areas retain growth and economical vitality while others remain stable or decline in Finland (see Perrels et al, 2005). Simultaneously the sparsely populated areas of Finland are increasing. This demographic and regional dynamics faced by urban and rural populations may increase the vulnerability to climate change induced health consequences in Finland.

4. Impacts in Finland

There is a quite high confidence that a prediction of climate warming during the forthcoming decades will not pose particular new risks for the population of Finland. Heat-related mortality and morbidity will be increased slightly, but simultaneously wintertime mortality and morbidity will decrease under a warming environmental temperature. Future climate scenarios include increasing number and severity of extreme weather events occurring in Finland. Short-term extreme weather events, both extensive heat and cold, will probably cause most of additional burden of climate induced direct adverse health outcomes and extra deaths in Finland (ACIA 2005; Kirch et al. 2005). We suggest that health consequences related to exposure to cold in Finland will remain common and represent the majority of climate-related adverse health effects also in the future.

The human thermoregulatory system may be activated even at +15 °C, but as many studies have showed (Hassi 2005; Rytkönen and Hassi 2005; Rytkönen et al. 2005), many subjective responses begin to develop at much lower temperatures. For example, cold weather may provoke respiratory symptoms and pulmonary obstruction. In northern Finland 47% – 78% of adult asthmatics reported shortness of breath in cold weather, while the corresponding figures for healthy adults were 3% – 13% (Kotaniemi et al. 2003). Respiratory symptoms and pulmonary obstruction provoked by cold may lead to decline in working capacity in cold (Hassi et al. 2005b). The occurrence of cold-induced symptoms increases among persons with a pre-existing chronic disease. The median of the self-reported turn-up temperatures of the cold-related symptoms is approximately –15°C in Finland (Rytkönen et al. 2005). When the temperature falls, cardiovascular symptoms are the first to appear, followed by respiratory symptoms, white fingers, peripheral circular and musculoskeletal symptoms. Finally, outdoor activity becomes difficult or even restricted in extreme cold (below –25°C) due to increased symptoms and other complaints. These findings based on the self-rated health adverse health effects allow us suggest that cold climate poses a range of challenges to the health of the Finnish populations and causes a clear economic burden in terms of lost productivity and costs to the health care systems also in a warming climate. The number of days, when the ambient temperature is below 0°C degrees, will also be prominent in the future. The aging population and the process of urbanization in some extent may accelerate the emergence of health problems induced by cold climate and extreme weather events.

Cooling injuries are linked to body cooling, but unintentional main injuries are associated with a more complex relationship with environmental cold (Hassi et al. 2005b). The risk for hypothermia cases will diminish along with milder winters. The most at risk will be elderly citizens and people abusing narcotics or alcohol and patients using drugs that affect the central nervous system and behaviour. Frostbite will also still remain a common cold injury in Finnish population. Complications related to frostbites will lead to persistent function limitations and disability among many individuals. Young urban dwellers may have an increased high risk to frostbite (Juopperi et al. 2003).

The rate of slip and fall injuries may increase with more intense precipitation events and possible increase in peak wind speeds in wintertime. Increasing rates of these injuries are seen at 0°C and colder environmental temperatures (Hassi et al. 2005b). Furthermore, thinner and shorter endurance of ice-cover of waterways will increase the risk of fatal accidents.

The region of Finland is one of the bellwethers for stratospheric ozone depletion and will, therefore, be the first to experience impacts due to increases in solar UV-B radiation. The impacts of these are incompletely understood and cannot be predicted with certainty. UV-B impacts on human health are much unknown, unclear and uncertain. Skin cancer appears to be a low risk phenomenon in the Arctic indigenous populations. Prediction of UV-B health impacts in the future can not be done reliable (De Fabo 2005). Local UV-B load to northern inhabitants is low compared to populations living in more southern latitudes.

In a warming climate the increase of atmospheric pollen is probable, which will be strenuous for the many allergic individuals.

Climate change could cause changes in the incidence of infectious diseases in Finland. Higher ambient temperatures may result in an increase in some temperature sensitive foodborne diseases such as gastroenteritis, poisoning and botulism. An increase in mean temperature may also influence the incidence of infectious diseases of animals that are spread to humans (zoonoses) by changing the population and range of animal hosts and insect vectors. An increase in flooding events may result in outbreaks of waterborne infection. A change in rodent and fox populations may result in an increase in rabies or echinococcosis. Temperature and humidity influence the distribution and density of many arthropod vectors which in turn may influence the incidence and northern range of vectorborne diseases such as West Nile virus (Parkinson and Butler 2005).

The most of the immediate adverse health effects in the future are caused by short-term climatic variability in the context of long-term climate change (Greenough et al. 2001; McGeehin and Mirabelli 2001). The projected impacts of climate change will be diverse in character and severity, and specific to particular places, population characteristics, equity aspects and public health infrastructure (Patz and Kovats 2002; Watson et al. 2005). For example, localized warming can be intensified in those few sprawling cities of Finland through the "urban heat island" effect. At increased risk are elderly and children, and those with poor health and chronic diseases.

5. Research needs – impacts

Many of the potential health impacts of climate change are indirect or non-linear which makes causal links very difficult to establish. It is complicated to project an association between future climate and health due to the lack of information about the current association between climate and health. There are many unsolved empirical questions about the sensitivity of particular health outcomes to extreme weather events, and the effects of climate and climate-induced changes in environmental conditions on health. There are also great uncertainties in projection of the future health status of a population. Furthermore, there are uncertainties related to future development of technological innovations in medicine and health care which in turn have a crucial impact on the population health. In general, measurement and estimation of the impacts of climate change includes identifying effects over a baseline period, but the human health-climate association baseline is not yet fully known.

More information is needed about which weather variables are important in the relationship between weather and health. Maximum temperature, minimum temperature, relative humidity, Heat Index (HI), and duration of exposure are currently used to estimate exposure to heat. Further research to determine the importance of each of these factors will improve estimation of the relationship between climate and health and facilitate precautionary measures as the thresholds of the key parameters are reached.

Assessment of the environmental and health consequences of extreme weather events has highlighted a number of knowledge gaps and problems in public health responses. In the past, cold and hot spells were not considered a serious risk to human health with "epidemic" potential in the European Region. In order to reduce the health impacts of future warming and extreme weather events, a characterization of the relationship between cold and heat exposure and human health must be put under scrutiny in Finland. Also other fundamental questions need to be addressed, such as whether the cold and hot spells and their adverse health effects can be predicted and prevented, and how this may be done.

More information is also needed about human susceptibility to climate change. Most susceptible are patients with certain chronic medical conditions, such as cardiovascular and cerebrovascular diseases, diabetes, respiratory and renal diseases, Parkinson's disease, Alzheimer's disease, and epilepsy. These conditions predispose patients to cold- and heat-induced adverse health outcomes such as frostbites, dehydration, heat exhaustion, and heat stroke. Increased awareness among healthcare providers that individuals with these conditions are at higher risk allows for guided intervention.

Cold climate related health risks are still poorly defined in Finland. Exposure to cold cause most of the adverse health outcomes and performance limitations, which in turn can be seen in lowered productivity and higher costs related to the health care system in Finland. The majority of the adverse health outcomes are milder than death, and in the Finnish society and by health care professionals weakly recognized. In order to provide preventive and protective public health actions for cold-induced adverse health effects now and in the future, it is important to achieve more scientific information on cold exposure patterns, cold injuries, cold-induced illnesses and symptoms and their threshold temperatures of appearance, and to identify the-most-at risk population subgroups and factors that increase or decrease the health risks of cold climate.

6. Adaptation

Population would adjust successfully, with little increase in heat related mortality, to the global warming of around 2°C predicted to occur in the next half century (Keatinge et al. 2000b). Winter excess mortality is nearly 5 %, while heat-related excess mortality comprises only 0.2-0.4 % of all annual deaths in Finland (The Eurowinter Group 1997; Näyhä 2005). A warming climate around 2°C will not change relation of this mortality pattern: cold-related mortality presents majority of excess death also in the future in Finland. The long-term influence of climate change upon health risk can not be directly compared with studies focusing on the health effects of marked short-term fluctuations in weather (Martens 1998).

The extent to which human health is affected depends on: the exposures of populations to climate change and its environmental consequences, the sensitivity of the population to the exposure, and the adaptive capacity of the systems, society, populations and individuals. If the adaptive capacity of the system or population is insufficient, even slight changes in climate may have severe adverse health outcomes.

Vulnerability of a population to a health risk in general depends on such factors as population density, level of economic and technological development, local environmental conditions, preexisting health status, and the quality and availability of health care and public health infrastructure. Awareness of the risks decreases the vulnerability. In the context of climate change and health, the vulnerability of a population can be defined as a function of the extent to which health is sensitive to changes in climate; the capacity of the population to adapt to new climatic conditions; and exposure to the climate-induced hazards (Bernard and Ebi 2001). Adaptation involves individual physiological ability to adapt, the ability to change human behavior and to modify health and other type infrastructure (housing, transportation, energy, etc) to reduce potential negative impacts. Adaptation is a function of several societal variables that in turn depend on competing demands and on the political, social and economic circumstances. Adaptation can be anticipatory or responsive and can include both spontaneous responses by individuals and planned/managed responses by governments and institutions.

It is crucial to understand what demographic or geographic subpopulations may be most at risk in the future in order to target effective prevention or adaptation strategies. For example, Davies et al. found that heat waves can be easily linked to high mortality events in most U.S. metropolitan areas and also the sensitivity of the urban and suburban population to heat has decreased over time (Davies 2005). Similar development has been reported in Finland (Näyhä 2005).These results provide strong evidence of ongoing societal adaptation to extreme summer weather conditions. The mechanism of adaptation probably includes increased access to technological innovations such as air conditioning systems, but also reflects biophysical adaptive responses and improved behaviour of individuals based on their awareness to risk. Adaptation takes place at several levels and therefore the roles of individuals, communities, nations, institutions and the private sector have to be considered in the planning of adaptation strategies.

However, physiological adaptation responses are not developed to cope with short-term hazardous or extreme weather events. The adaptive capacity of the Finnish society is fairly good as we are able to maintain a public health infrastructure and achieve sustainable political and economic development. However, an aging and chronically sick population having cold related diseases, together with threats posed by climate need to be underlined. Although acclimatization takes place in a relatively short period of time, behavioral changes especially among the most at risk populations are required as part of beneficial adjustment. Urbanization may decrease the adaptive capacity as urban populations are known to cope less well with harsh climatic conditions than their counterparts in rural areas (Juopperi et al. 2002). Spontaneous adjustments to extreme heat might not compensate fully for effects of future heat waves in Finland. Adaptive capacity is also a function of current population health status and pre-existing disease burdens.

To improve the adaptive capacity of Finnish society to future climate-health risks will require, for example:

1. Sufficient financial resources, technology, and public health infrastructure. Public health infrastructure may be the "most important and cost-effective" adaptation strategy.
2. Awareness-raising and preparedness, in particular through information on the risks associated with health and climate as well climate change

3. Early-warning systems and public education programmes. This includes public health training and distribution of information, more effective surveillance and emergency response systems, and sustainable prevention and control programs
4. Institutions and an environment that enables people to receive and use information

In a warming climate infectious diseases need improved awareness and surveillance in Finland. Recommendations also include: the maintenance of public health systems, disease surveillance coordinated with climate monitoring, and research into the detection, prevention, control and treatment of temperature-sensitive infectious diseases (Parkinson and Butler 2005).

A rising awareness among populations at risk may be a very effective manner by which the health-related risks associated with climatic change can be reduced. As the WHO (2001) states: "Capacity building will certainly be an important step for adapting to climatic change, enabling people to take well-informed decisions for the long-term benefit of society."

7. Research needs and priorities – adaptation

The focus of the future studies should:

1. Outline/update the current knowledge about the Finnish risks posed by climate for human health
2. To identify detailing the most vulnerable systems and population
3. To identify the factors that determine the vulnerability of human systems to extreme weather events, climate variability and change, and how vulnerability can be reduced in policy action levels.

There is an emerging need for improved collaboration between health care, weather broadcasting and other administrative agencies in order to produce usable preventive model for action and proactive measures. The definition of public health programmes aimed at preventing heat- and cold-related mortality and morbidity needs further research and development. The prevention of cold injuries and illnesses is much the responsibility of health care providers, who require practical information and education to be able to offer professional support to main population.

We need more information on climate-health warning systems, as well as cost-benefit analyses of the provision of public space cooling in particular locations. It is necessary to develop public advice and community-based activities that support the social and medical welfare of the elderly and other high-risk groups in order to reduce their vulnerability to temperature extremes.

We need a greater understanding of the importance of urban design to anomalous and hazardous weather.

We need more information about the measures and technological tools that can be targeted at reaching subpopulations most at risk.

Cost-benefit analyses of climate related health losses is a good support to get societal resources for the development and research actions nominated before.

8. Conclusions

Global climate change has the potential to influence adversely the health of people around the world. In Finland, heat-related mortality may increase in the future. Cold spells will remain a problem even under a warming climate, and winter mortality will still present the majority of excess temperature-related mortality. The people most likely to be adversely affected by long-term climate change and short-term climatic variability and extreme events are the elderly and those having a pre-existing disease, with those living in urban environments especially at increased risk. Children and teenagers in urban milieus also need attention.

The human health impacts of climatic change will depend on many factors, including existing infrastructure, financial resources, technology, access to adequate health care facilities and equity across different regions. In Finland, climate change is only one among many exacerbating factors that influence health; other factors are likely to be more influential. The population of Finland is ageing and becoming more urbanized, which may decrease the adaptive capacity of Finnish society.

There are still many gaps in knowledge about current and likely future health risks related to climate, its change, climate variability and extreme weather events. The future research in Finland should aim to increase epidemiological knowledge on both direct and indirect health impacts of climate change, of climate variability and of extreme weather events, should produce spatially defined and subpopulation specific information on the climate induced health risks and should finally offer recommendations and good care practices to be utilized in the health care sector and by decision-makers. Awareness building based on the scientific facts of the climate-health relationship is probably the best alternative to tackle with climate induced health risks. Research carried out elsewhere in Europe does not necessary fulfil the needs of our society in its much colder environment. Knowledge gaps can be beneficially filled and awareness raised only through extensive research closely connected to actual circumstances. We should also consider if there is a need for climate-health warning systems in Finland. It is not yet known whether the use of heat or cold warnings would significantly change the behaviour of the general public. In many parts of the world health warning systems have already been developed and implemented in practice to reduce adverse health effects of anomalous weather events.

The adaptation measures identified in any climate change health impact assessment are of importance regardless of future climate change. In other words, the work to develop adaptation strategies should be considered beneficial, even if climate change scenarios and their projected health impacts were to prove inaccurate. “No individual technology or policy will achieve the effort that will be needed over a long period of time. Rather, we need processes that will trigger and support sustained efforts to better understand both causes and effects over many decades, and aid us to adapt these in response to evolving new scientific knowledge about climate-change and its impacts, along with technological, institutional, and social capacity for mitigation and adaptation” (Watson et al. 2005).

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Julkaisun nimi	Ilmaston lämpeneminen ja siihen sopeutuminen ihmisen terveyden kannalta	
Julkaisun osat/ muut saman projektin tuottamat julkaisut		
Tiivistelmä	Ilmaston lämpenemisen seurauksena suomalaisten terveysriskit muuttuvat jonkin verran nykyisestä. Helteisiin liittyvät kuolemat ja sairaustapaukset tulevat lisääntymään. Toisaalta kylmien talvikuukausien aiheuttamat terveyshaitat tulevat vähenemään nykyisestä. Ilmaston ja sään lyhytaikaiset ääri-ilmiöt voimistuvat ilmastonmuutoksen myötä ja aiheuttavat todennäköisesti suurimman osan ilmastoriippuvaisista terveyshaitoista. Riskiryhmään kuuluvat vanhusväestö ja lapset sekä ne, joilla on huono terveys. Ilmaston muutoksen välilliset terveyshaitoista infektiosairauksien lisääntyminen liittyen ilmaston lämpenemiseen ja vesistöjen tulvimiseen lienevät monimuotoisimpia. Näihin kuuluvat myös erilaiset eläinvälitteiset sairaudet. Hellekuolemien hienoisesta noususta huolimatta suomalaiset tulevat sopeutumaan varsin hyvin ilmaston hitaaseen lämpenemiseen. Sen sijaan ihmisen sopeutumismekanismit eivät ehdi kehittyä vastamaan niihin muuutoksiin, joita aiheutuu ilmaston ja sään ääri-ilmiöistä. Suomalaisen yhteiskunnan kyky sopeutua ilmastomuutoksen tuomiin haasteisiin on verrattain hyvä, jos yhteiskunta kykenee ylläpitämään terveyssektorin infrastruktuurin toimintakykyisenä ja jos taloudellinenja poliittinen kehitys jatkuu vakaana. Ilmastomuutoksen terveyshaittojen erityiset riskiryhmät ovat ikääntynyt väestö ja lapset sekä urbanisoituneet kylmänhallintataidoiltaan aikaisempaa vaatimattomammat nuoret. Suuren riskiryhmän muodostavat kylmäsairauksia ja allergioita potevat suomalaiset, joita on noin kolmannes väestöstä.	
Asiasanat	kuolleisuus, oireet, ääri-ilmiöt, kylmä, helle, paleltumat, tapaturmat	
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In Finland, heat-related mortality may increase in the future. Cold spells will remain a problem within Finland even under a warming climate, and seasonal mortality during winters will still present the majority of excess temperature-related mortality. The people most likely to be adversely affected by a long-term climate change and short-term climatic variability and extreme events are the elderly, children and those having a pre-existing disease; especially those living in urban environments are at increasing risk.

The adaptive capacity of Finnish society is fairly good as we are able to maintain the public health infrastructure and achieve sustainable political and economic development. Threats posed by climate have to be considered with context of an ageing population. Although acclimatization takes place in a relatively short period of time, behavioural changes are required as part of beneficial adjustment. The ageing population along, with urbanization, may decrease the adaptive capacity.

Ilmaston muutoksen välittömät terveyshaitat liittyvät lämpimien ja hellepäivien lisääntymisestä aiheutuvaan kuumakuolleisuuden ja muiden kuumakuormituksen terveyshaittojen yleistymiseen. Myös ilmaston muutoksen myötä pääosilta ilmaston kylmyydestä aiheutuva ylikuolleisuus ja hyvin yleiset kylmän terveyshaitat säilyvät merkittävimpänä ilmaston terveyshaittana Suomessa. Suuren riskiryhmän muodostavat ikääntynyt väestö, lapset, kylmäsairauksia ja allergioita potevat suomalaiset, ja näistä ryhmistä erityiset ne, jotka asuvat kaupungeissa.

Suomalaisen yhteiskunnan kyky sopeutua ilmastomuutoksen tuomiin haasteisiin on verrattain hyvä, jos yhteiskunta kykenee ylläpitämään terveyssektorin infrastruktuurin toimintakykyisenä ja jos taloudellinen ja poliittinen kehitys jatkuu vakaana. Väestön vanheneminen ja taajama-asutuksen lisääntyminen voivat vähentää suomalaisen yhteiskunnan sopeutumiskykyä ilmastomuutoksen tuomiin haasteisiin.

This report is also available at the FINADAPT Web site:
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