Expert elicitation on uncertainty, climate change and human health

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November 2010

Report commissioned by: Netherlands Environmental Assessment Agency (PBL)
Deliverable of project: Case-studies uncertainty and climate change adaptation

Report NWS-E-2010-71
ISBN: 978-90-8672-047-7

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1. Introduction

Climate change may have a range of diverse effects on human health, ranging from increased heat-related disease and mortality to effects on vector-borne diseases and allergic disorders such as hay fever. Assessments for the Netherlands have indicated a number of effects that are considered relevant for the country, but indicate many knowledge gaps and uncertainties and note that quantification of impacts is difficult (MNP, 2006; Huynen et al., 2008). This makes it complicated to decide whether - and if so how much - adaptation to these various impacts is needed.

Dessai and van der Sluijs (2007) assess that there are large differences in the level of uncertainty that various adaptation approaches can accommodate. Some approaches require detailed knowledge, while others function well in the face of ignorance (but may have other tradeoffs). Therefore, decision-making on these issues requires a good understanding of the state of knowledge and the associated uncertainties, in order to develop adaptation strategies that are fit for function. This study assesses the degree of uncertainty for the health effects of climate change in the Netherlands, and the policy implications of this uncertainty, by means of an in-depth expert elicitation.

1.1. Background of this report

In 2007, the Copernicus Institute has inventoried the different types of uncertainty that play a role in climate change adaptation and different approaches to dealing with this uncertainty (Dessai and Van der Sluijs, 2007). The study was commissioned by the Netherlands Environmental Assessment Agency. Following this 'scoping study', several case-studies have been performed in 2008-2009 to explore how the results could be applied to actual cases in climate adaptation in the Netherlands. This project consists of three cases: the advice of the Delta Committee, adaptation of natural areas (Wadden Sea), and human health.

The present report presents the case study of the third case: human health. Three questions are central to the study: (a) what level of uncertainty is associated with each potential health effect for the Netherlands?, (b) which health effects are most relevant for Dutch climate change adaptation policy?, and (c) which policies could either cope very well with the uncertainties or be very sensitive to these? The main focus is on question (a).

1.2. Reading guide

The first part of this report (*Chapter 3*) assesses the level of uncertainty for various potential health effects. The second part (*Chapter 4*) examines the policy implications of the uncertainties by looking at: the relevance of various effects for adaptation policy (*par. 4.1*) and which policies would be either robust or vulnerable to the uncertainties (*par. 4.2*). The conclusions provide a short overview of the results (*Chapter 5*).

2. Methods

This chapter provides an overview of the methodological setup of this study. Specific details can be found in the appendices: a list of the participants and their characteristics (*Appendix A*) and the survey protocol (*Appendix B*).

2.1. Approach

This study preformed an expert elicitation on uncertainty in relation to climate change and health. The focus was on the Netherlands. The survey was split in two parts: (I) the levels of uncertainty for various health effects, and (II) the implications of these for adaptation policy.

The elicitation was performed by means of an online survey. The survey used both quantitative and qualitative questions: respondents were asked to provide scores and provide argumentations for these scores. While including argumentative questions can be expected to reduce the response rate, they are essential to: (a) provide meaning to the scores (why do experts believe what they believe?), (b) analyze the reasons for different scorings among experts, and (c) allow the experts to consciously and deliberately assess the available evidence and reasons for giving a certain score (in principle resulting in a score that better represents the actual situation than a 'first glance' scoring).

During the first (and main) part of the survey, experts were asked to indicate: 'Regarding the following specific health issues, with what level of precision would you be able to estimate the magnitude of the health risk for the Netherlands (due to climate change)? Assume you would be given some time to review the relevant literature, before you would make the effect estimate'[1]. Respondents scored this on the 'level of precision' scale in *Table 1*. The 'level of precision' is taken as a proxy for the 'level of uncertainty'. It relates not to the magnitude of the uncertainty (e.g. plus or minus x%) or the health effect, but to the degree to which these can be quantified at all, given the present state of knowledge.

Table 1. Level of precision scale (based on: Risbey en Kandlikar, 2007; Slottje et al., 2008).

Rating:	Label:	Description:
1	Effective ignorance	Knowledge of the factors that govern this effect is so weak that we are effectively ignorant.
2	Ambiguous sign or trend	Some effect is expected, but its sign or trend is not clear. There are plausible arguments either direction (effect could be positive, could be negative; could increase or decrease).
3	Expected sign or trend	It is clear what the sign and trend of the effect will be. However, there is no plausible or reliable information on how strong it will be.
4	Order of magnitude	It is possible to give a rough indication of the magnitude of the effect, a qualitative scoring (e.g. 1-10 scale), or a rough comparison with other effects.
5	Bounds	It is possible to estimate the bounds for the distribution of the effect, e.g. its 5/95 percentiles (effect is only 5% likely to be more than … and only 5% likely to be less than …). However, the shape of the distribution, or best-guess estimates, cannot be provided.
6	Full probability density function	It is possible to provide a full probability density function; the bounds as well as the shape of the distribution.
N/A	Don't know / no answer	

[1] Note that this question does not specify that the estimate should be made for a single scenario. Thus, due to the existence of multiple climate scenarios, a rating of 6 (full probability density function) is unlikely to be given. This limit to the level of precision is inherent in the policy-decision situation.

Participants scored this for a list of health effects that were deemed relevant for the Netherlands (*Table 2*). This shortlist was based on existing effect-inventories for the Netherlands: MNP (2006), Huynen et al. (2008), and internal memos of the Health Council of the Netherlands leading up to GR (2009). The draft list was checked and supplemented by several experts in this field of study. The health effects are grouped in eight 'themes': temperature, allergies, pests, vector-borne diseases, food/water-borne diseases, air quality-related effects, flooding/storm-related effects, and UV-related effects. Participants scored and provided arguments for one theme, then moved to the next. Any question, section or theme could be left unanswered if desired. An open question at the end provided room for respondents to indicate and rate any health effects that were considered relevant but had not been included in the shortlist.

Table 2. Shortlist of potential health effects of climate change in the Netherlands.

1. Temperature: Heat-related mortality
2. Temperature: Heat-related cardiovascular problems
3. Temperature: Heat-related respiratory problems
4. Temperature: Heat-related stress and sleep disturbance
5. Temperature: Cold-related mortality
6. Temperature: Cold-related diseases
7. Temperature: Drought-related exposure to contaminants
8. Temperature: Shortages of drinking water
9. Temperature: Dehydration
10. Allergies: Asthma
11. Allergies: Allergic eczema
12. Allergies: Hay fever: duration of pollen season
13. Allergies: Hay fever: pollen types, abundance and allergenicity
14. Pests: Wasps
15. Pests: Oak processionary caterpillar
16. Vector-borne: Native vector-borne diseases
17. Vector-borne: Incidents of non-native vector-borne diseases
18. Vector-borne: Epidemics of non-native vector-borne diseases
19. Food/water-borne: Food poisoning
20. Food/water-borne: Legionnaires Disease
21. Food/water-borne: Contamination of swimming/recreation water
22. Air quality: Respiratory problems due to ground-level ozone
23. Air quality: Respiratory problems due to particulate matter
24. Air quality: Air quality-related cardiovascular problems
25. Flood/storm: Flood-related mortality
26. Flood/storm: Flood-related infectious diseases
27. Flood/storm: Flood-related exposure to dangerous substances and contaminants
28. Flood/storm: Flood-related respiratory problems
29. Flood/storm: Flood-related mental health problems
30. Flood/storm: Storm-related mortality and injury
31. UV: Cataract
32. UV: Skin cancer
33. UV: Weakening of the immune system
34. OTHER (please indicate)

During the second part of the survey, respondents were asked to indicate and rank the five health effects they considered most 'relevant' for Dutch climate adaptation policy in view of public health. They were asked to interpret this in a broad way, taking into account the possible magnitude of the health impact, economic impact, public and political perception, and the availability of options for adaptation and control. For these, respondents were asked to indicate: (a) why this was relevant, (b) what specific uncertainties play a role in estimating the magnitude of the health risk, and (c) what adaptation options/strategies would be particularly well-capable of dealing with these uncertainties or would be very vulnerable to them (and why).

The responses to the qualitative questions were analysed for: (a) the lines of argument, (b) the similarities, differences and consistency of arguments for various scores, and (c) the consistency between different arguments for the same score. Responses were coded for:

- Participant number (for cross-checking arguments per participant)
- Score given in the associated quantitative question
- Participant has key expertise on this specific health theme
- Participant is adaptation expert (for adaptation-related questions)
- Reason for limit to precision (score isn't higher because…)
- Reason for attributing precision (score isn't lower because…)
- Possible score bias due to mix with adaptation
- Possible score bias due to other factors (does not believe in climate change, does not believe that specific health effect will occur, disagrees with formulation of effect, score based on self-reported lack of knowledge of respondent)

2.2. Sample

A list of potential respondents was drafted based on suggestions from experts in the field of study. A base list of Dutch experts (N=97) was supplemented with a number of international experts (N=13), and Belgian experts (N=24), totalling 134 experts invited. A sub-list of 35 experts was flagged as 'particularly relevant' for this study. The Dutch list included scientists, as well as policymakers and health practitioners (local/regional health services, medical professionals, etc.). Invitees received an invitation by e-mail with a link to the online survey plus a briefing note (attached as pdf document). The online survey page included both a link to the briefing note and a Word document of the survey, for those respondents who preferred to fill out the survey offline. A reminder was sent after several weeks.

A total of 21 experts participated (one of whom by an e-mail), giving a response rate of 16%. Of the sub-list of particularly relevant experts, 11 replied, giving a response rate of 31% for this subgroup. An overview of participant characteristics and backgrounds can be found in *Appendix A*. The main reasons for declining to participate included: (a) lack of time, (b) (perceived) lack of expertise. Other factors that may have led to non-response include: multiple invitees per department/organisation (which may lead to invitees to consider their (organisation's) views to be already included) and a relatively large number of high-level (directors, etc.) invitees. The base response rate is relatively low compared to what is generally expected for web-based surveys (e.g. Cook et al. (2000, fig.1) indicate ca. 20-50%, mean 30%, assuming 1 follow-up; note that the rate for the 'particularly relevant' subgroup is in line with this). However, this is to be expected for the type of survey employed in this study; a long, argumentative (i.e. many open-ended questions) assessment on a relatively technical subject. Response rates cannot be readily compared to, for instance, short, multiple-choice opinion polls. In addition, the survey did not aim to assess opinions, but to perform an expert elicitation (response rates are less important for the latter than the former).

Expert elicitations generally aim for approximately 6-12 experts to participate (Cooke and Probst, 2006). The total number of survey respondents well exceeds this number. Individual quantitative questions were answered by 8-17 (mean: 12.6, median: 12) respondents (see *Appendix C*); well within this range as well. Measures of expert competence or performance ('seed variables') are sometimes employed, for example to weight individual scores when combining them into one total score. In this survey, respondents were asked to indicate whether they were 'generalist' experts on climate change and health and/or were 'subject-matter' experts on specific themes, such as temperature, allergies, climate adaptation, et cetera, (cf. Kotra et al., 1996; Slottje et al., 2008). This report will refer to the subject-matter experts as 'key experts'. This distinction was used both for weighting and for interpreting differences in scoring and arguments. Furthermore, respondents were asked to answer only the questions they considered themselves capable of answering (self-assessed competence) and the argumentation provided a further check on the salience of scores.

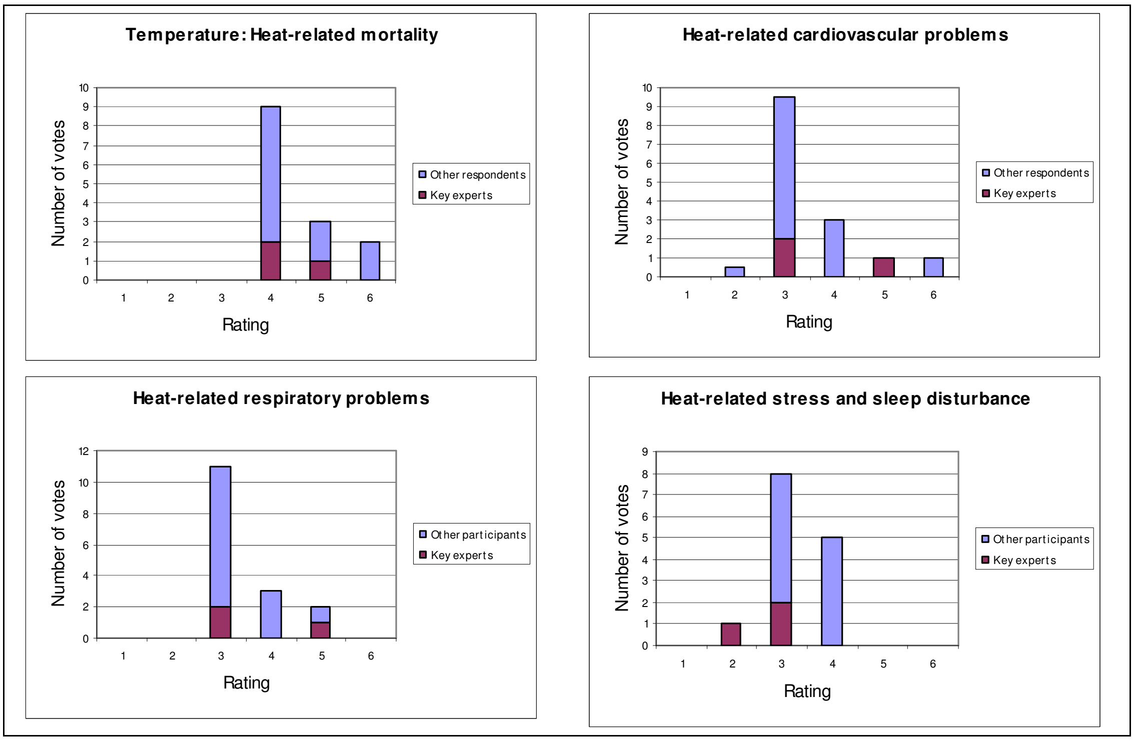
3. Level of uncertainty

Respondents were asked to indicate the 'level of precision' with which they could estimate the magnitude of each health risk at the present state of knowledge for each item on the list of health issues (also taking into account interactions between issues). A high the level of precision can be understood as a low *level* of uncertainty/ignorance[2]. This chapter will discuss the scores and arguments, per category of effects. *Paragraph 3.9* will present an overview of the ranges and median scores for all health issues.

3.1. Temperature

Figure 1 shows the scores for temperature-related health effects of climate change. Most heat- and cold-related effects show a clear peak in their scores, indicating convergence of expert opinion. For heat- and cold-related mortality, the respondents indicate that the 'order of magnitude' (score: 4) of health effects can be assessed. For other effects, the 'expected sign/trend' (score: 3) can be indicated. For stress and sleep disturbance, a large minority scores 4, while the key experts score 2-3. While there are clear peaks for cold-related effects, there are substantial differences in individual scores, also among the key experts. For indirect effects of temperature, such as shortages of drinking water and dehydration, scores vary between 2 and 4 approximately, with no clear peaks.

Scores per participant often followed a consistent pattern of high for heat-related mortality and slightly lower for other heat-related effects. This pattern is also visible for cold-related effects, albeit slightly less consistent. No pattern was visible for indirect effects.



[2] Note that the magnitude/range of uncertainty in terms of health effects can still be large, even if it is possible to provide bounds or a full probability density function.

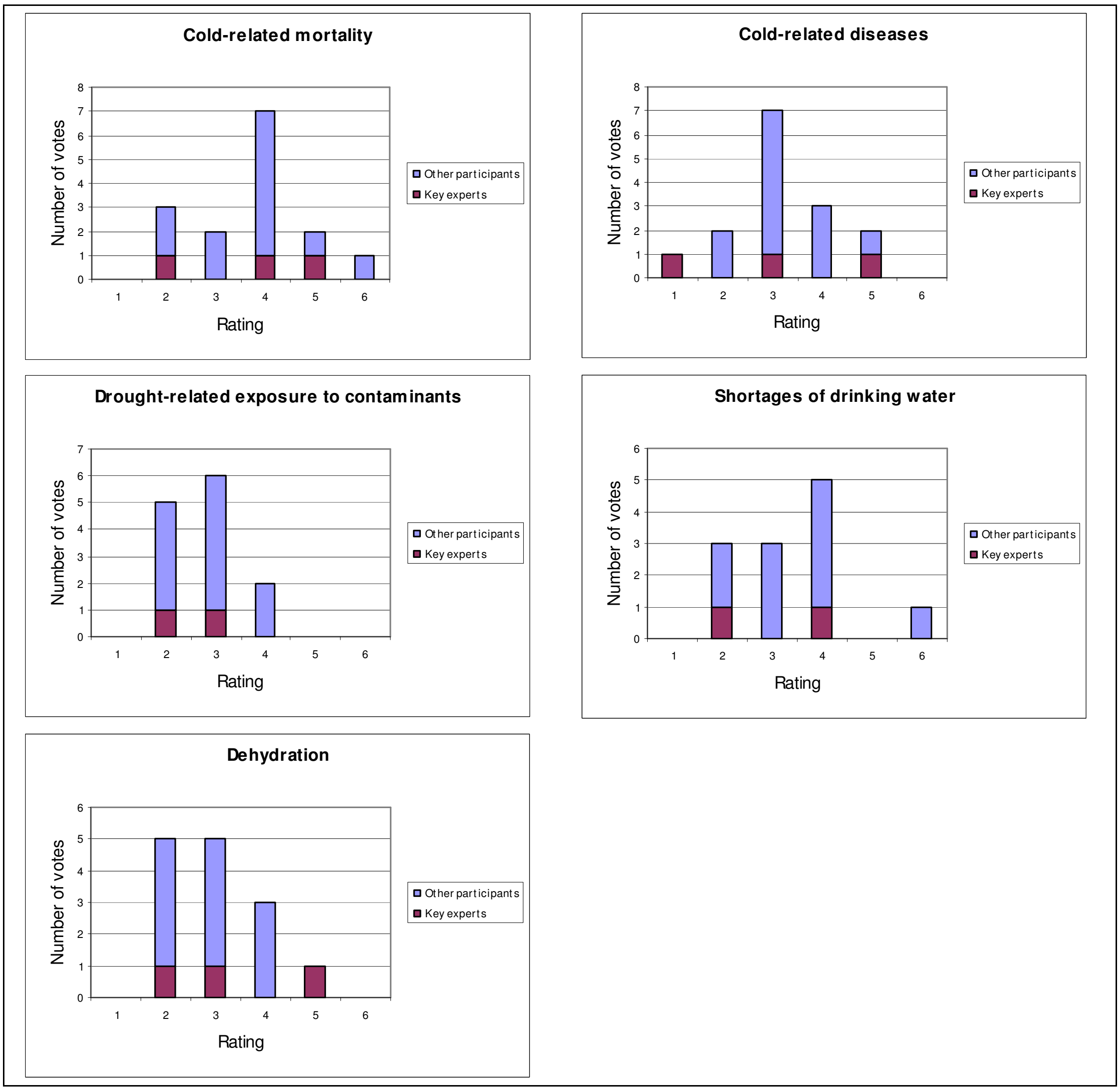


Figure 1. Scores for temperature-related health effects.

Heat-related effects

The arguments for *heat-related mortality* consistently state that much data, experience, and literature is available on the relationship between heat and mortality. Arguments for 'bounds' (5) only stress the body of literature. One respondent who rated 'full probability density function (6) stated that if little information would be available, it wouldn't be difficult to tune a model for mortality surveillance or expected mortality, and that this had already been done in France. Arguments for 'order of magnitude' (4) indicate a number of factors that limit the level of precision of projections. The respondents do not all mention the same factors. However, the factors mentioned are complementary, and taken together would be consistent and likely not change the scoring. The arguments follow the general point that, as one respondent put it, the effects are known, but the specific context is not. Factors mentioned include:

- limited empirical information for the Dutch situation specifically,
- confounders and interactions with other factors (e.g. socio-economic, air quality, demographics, harvesting effect) which may change in the future,
- possible changes of the response function (e.g. due to autonomous adaptation),
- limited knowledge on the reasons behind reported differences in response functions in various places in the world,
- difficulties in estimating/modelling the future intensity, duration, and frequency of heat waves.

Two key experts also noted for this health effect (as well as for the other heat-related effects) that there are uncertainties in adaptive capacity and the impact of adaptation measures. This is a separate issue. One could estimate effects without policy (to assess the impacts and whether adaptation measures would be needed), as well as with policy (to assess the effect of measures)[3]. The survey aimed for the first question, as is often the case in estimating climate impacts. Both experts stated other arguments that would lead to the same score. Thus, it seems unlikely that this difference in interpretation affected the results. Related to adaptation, one key expert noted in an e-mail response that, while there is plenty of statistical evidence, there is a lack of good studies on the *why* of heat-related mortality. This lack of insight limits the level of precision, but also makes it difficult to assess whether and how interventions would need to be made.

For the peak score of *heat-related cardiovascular problems, respiratory problems, and stress and sleep disturbance* (in each case 3, 'expected sign or trend'), two lines of argument are visible. Some state that the effects are well-documented and expected, particularly for the elderly. Others note that there are a "few indications only", a limited amount of studies and none for the Netherlands specifically, and generally too little data to make a reliable estimate of the magnitude of the effect of climate change. In the case of respiratory problems, participants also point to combinatory effects with hay fever and air pollution (summer smog), both as an indication that effects are expected and as a confounding factor that limits the level of precision. The two lines of argument seem to approach the matter from different angles and slightly emphasise these to make their point: (a) there is enough evidence to expect a trend and (b) enough limitations to this evidence to make further assessments. Compared to heat-related mortality, these limitations are stronger, due to less data and less knowledge on the specific drivers for these effects. Arguments for higher scores (4-5) point to available literature, epidemiological data, and experiences and data from the heat waves of 2003.

Cold-related effects

Arguments for high scores on *cold-related mortality* (4-5), including by a key expert, present the same points as for heat-related mortality: much data is available, but there are some factors that limit the level of precision. Two different arguments are provided for low scores (2) on cold-related mortality. A non-key expert stated that, while less cold periods are expected, Dutch society can deal with such periods. This may be interpreted as: changes are expected, but their effect may be negligible. A key expert suggested that the proposed reduction in cold-related mortality depended on whether we can assume adaptation by shifting our optimal temperature (i.e. autonomous adaptation to the warmer climate). Should the wind circulation patterns over Europe change (KNMI'06 scenarios G+ and W+ (KNMI, 2006)), the difference between summer and winter temperatures could increase. If autonomous adaptation is assumed, winter mortality could actually increase[4]. These two lines of reasoning for low scores are opposite, but lead to similar conclusions: we can cope with cold, thus the effect may be zero, rather than positive, versus we may not be able to cope with cold in the future as well as today, thus the effect may be negative rather than positive.

High scores for *cold-related disease* (3-5) also list the same arguments as for heat-related disease: some data, but not enough to make estimates. For the low scores (1-2), the non-key expert provided the same arguments. The key expert (score: 1) indicated that while effects might be expected for cardiovascular and respiratory diseases, it is still unclear why influenza is a seasonal disease, implying a lack of knowledge about the current temperature-influenza relationship.

[3] Note that *autonomous* adaptation (e.g. physical responses, short-term reactive abatement options, etc.), which some other participants referred to throughout the survey, is not a problem in this respect, as it is also included in the 'no policy implemented' scenario.

[4] The expert referred to Huynen (2008), which does give order of magnitude estimates of this effect. Possibly, the low score could be a reaction to the explanation of "(decrease)" that was added to "cold-related mortality" in the questionnaire (see Appendix B).

Indirect effects

Drought-related exposure to contaminants scored mainly between 2 and 3. Arguments for 2 indicate that it is unknown how this would work out with a well-prepared societal care system, and that likelihood of occurrence of droughts that might result in such problems has never been estimated. Arguments for score 3 state that there are a few indications, but also point to a lack of data.

For *shortages of drinking water*, arguments for score 2 again point out that it is unknown how this will work out considering the well-prepared care system, and that there is a lack of data. A respondent who scored 3 suggests that there were some problems during the 2003 heat waves and that this will occur frequently in the future. Arguments for 4 point to existing reports and modelling. Another respondent suggests that a maximum order of magnitude could be suggested because of the availability of short term abatement options. One respondent suggested a score as high as 'full probability density function' (6), stating that shortages of drinking water would be "no problem whatsoever" (i.e. health effect is zero). This respondent suggested that the lack of cooling water for utilities and the effect of that on health would be a bigger problem.

The arguments for scores of 2 for *dehydration* again point to the well-prepared care system and lack of data, as well as the possibility of autonomous behavioural adaptation (as a factor that limits predictability). Arguments for high scores (4-5) point to existing literature, experience, and documentation of this effect in nursery homes.

3.2. Allergies

Figure 2 presents the scores for allergy-related health effects. The scores for asthma and allergic eczema are reasonably consistent: both score between 'ambiguous sign or trend' (2) and 'expected sign or trend' (3). For asthma, however, all key experts score 3. The scores for hay fever: duration of pollen season and pollen types/abundance/allergenicity are very consistent: both score 'expected sign or trend' (3). For duration of pollen season, one key expert scores 4, versus four scoring 3.

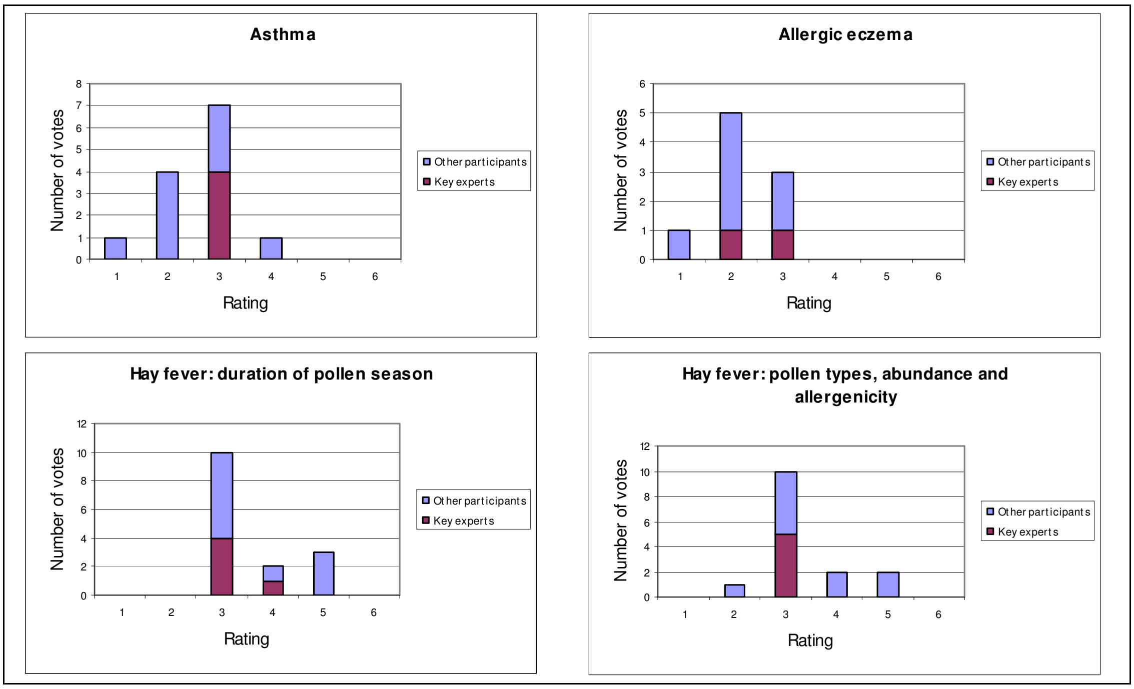


Figure 2. Scores for allergy-related health effects.

Asthma and allergic eczema

Arguments for the peak score for *asthma*, 'expected sign or trend' (3) indicate that asthma is associated with airway-related allergies, such as hay fever. The key experts deem it highly likely that changes in the timing, duration, allergenicity, type, and intensity of pollen will change (i.e. increase) health risks related to asthma. However, the available data is insufficient to quantify the health impacts under different climate scenarios. The fact that asthma is a highly multi-factoral issue also prevents quantification. The links between climate change, allergen release and allergen exposure, and limited research into the specific situation in the Netherlands provide specific uncertainties. Arguments for 'ambiguous sign or trend' (2) also point to this multicausality and add that some factors could change positively and others negatively (also over time: summer effects can be different from winter effects; a respondent refers to this as 'time integration'). It is unknown how these separate effects will add up. The respondent who scored 'effective ignorance' (1) argued that the category was too broad and that the interplay between determinants was unknown (consistent with the multicausality arguments above).

For *allergic eczema*, respondents provide the same arguments of multicausality, time integration, and lack of data.

Hay fever

The arguments for a score of 3 for *hay fever: duration of the pollen season* indicate that climate change is likely to increase the length of the pollen season. The impacts (health and socio-economic) can be substantial, as up to 15% of the people suffer from hay fever. However, the exact magnitude of the health impacts remains unclear. Two key experts note that the season has changed for some species, but not for others (e.g. for some it has started earlier, but stopped earlier as well). Other arguments include that, for grass pollen (the most important type), one of the two pollen counting stations in the Netherlands shows a change while the other does not, that allergy is a multi-factorial issue, and that it is not clear how pollen exposure and intensity (and hay fever incidence) will change due to longer pollen seasons. It is unclear how (and how fast) these things will change in the future and what the combined effect of all species will be. Arguments for score 5 indicate that there is a lot of recent literature and data. A key expert who rated 4 indicated that there is only limited data, but that rough estimations could be made.

One of the key experts who scored 3, noted that the magnitude of impacts "will largely depend on the response of patients and the medical sector to the changes in the duration of the pollen season". This is an adaptation argument, as discussed for temperature in paragraph 3.1 (not one of the experts who noted such arguments there). It is not fully clear from the rest of the argument how the respondent would have rated under a 'no policy' scenario. However, the 'response' argument also has a strong autonomous component (if no specific measures are taken, impacts still depend on how patients and medical sector will react), and the expert does specifically note that quantifications have not been made. The expert who scored 4 included the 'impact of adaptation measures' in his argument as well. However, the respondent rated other health effects at 4 using the same arguments minus 'adaptation'. Thus, an effect on the score can likely be excluded.

For *hay fever: pollen types, abundance and allergenicity*, respondents suggest a coherent set of changes. New species of plants may settle in the Netherlands, particularly Ragweed (Ambrosia) (imported via birdseed), Parietaria judaica, and the olive tree (popularity for gardens will likely increase). The number of locations where such plants are found is already increasing. However, the amount of ambrosia pollen has not yet increased. Furthermore, there is an increasing number of indications that the amount and allergenicity of pollen will increase, for example due to increased CO_2 concentrations and during situations with decreased air quality (which may become more prevalent due to warmer weather). The magnitude, nature, and tempo of health impacts are unknown, as are the interplay of determinants and the role of other factors that may favour these sorts of effects.

3.3. Pests

As shown in *Figure 3*, the opinions on the health effects of climate change via wasps are divided, ranging from 'effective ignorance' (1) to 'bounds' (5). The two key experts score the effect 'ambiguous sign or trend' (2) and 'expected sign or trend' (3) respectively. The health effects of climate change via the oak processionary caterpillar are very consistently estimated at 'order of magnitude' (4).

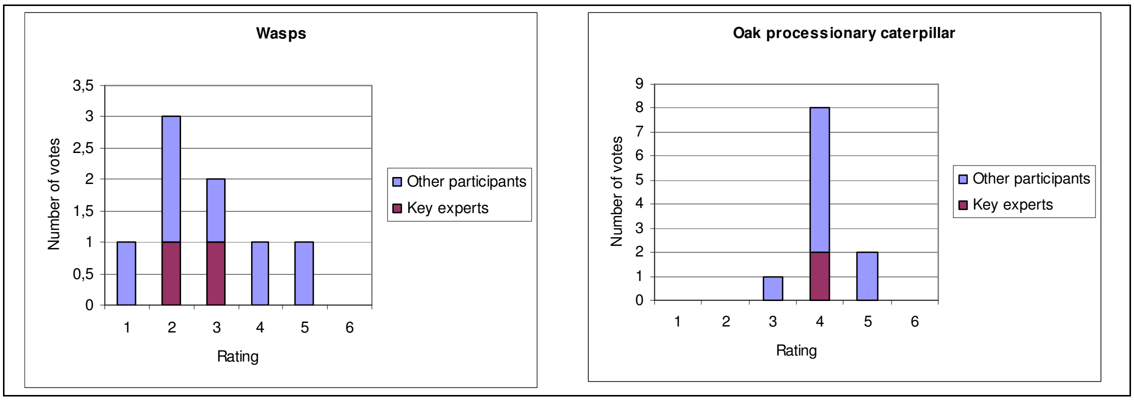


Figure 3. Scores voor ongediertegerelateerde gezondheidseffecten.

For *wasps*, the respondent who scored 1 indicated that the issue was new to him, as did one respondent who scored 2. These scores can be disregarded, as it is based on a lack of personal knowledge, rather than the overall body of knowledge, narrowing the scores to 2-5, with 2 and 3 chosen most often. The respondent who scored 4 ('bounds'), noted that the occurrence of hornets will become more likely, referring to extensive documentation from Japan. The key expert who rated 3, indicated only that there is a lack of data. Two respondents, including the other key expert, who rated 2 ('ambiguous sign or trend') noted that the queens of wasps are observed to wake up earlier in spring due to high winter and early spring temperatures, better weather conditions during the most vulnerable phase for queen wasps (April), resulting in a larger amount of wasp nests and wasps. As a few people die every year due to allergic reactions to wasp stings, this could have health implications. However, they note that the more frequent warm winters could also reduce queen wasp survival, e.g. when hibernation is disturbed during warm episodes, resulting in die-off during subsequent colder episodes.

The arguments for the effects of the *oak processionary caterpillar* present a consistent set of arguments for score 4: the caterpillar entered the south of the Netherlands in the 1990s and gradually expanded its distribution northwards. Based on the KNMI climate scenarios, it is expected to be present in the whole of the Netherlands in 2020 or earlier. Population size is expected to increase significantly, and as we are not able to remove caterpillars effectively and as their urticating hairs remain potent for eight years, many people are expected to face health complaints. Data exists on the spread and health impacts of the caterpillar, supplied by e.g. the Natuurkalender (Nature's Calendar) and the regional public health services (GGD). However, while rough disease estimates are available, the potential future magnitude of health impacts is not known (but rough estimates could be made).

One of the key experts suggested a third health issue related to climate change in the category 'pests': *mosquitoes*. It is expected that the mosquito season will lengthen and the number of mosquitoes will increase. This has implications for the quality of life of large numbers of people, e.g. through sleep disturbance. This will increase should other mosquito species, such as the Asian tiger mosquito (more painful sting and stings during the day as well, which native mosquitoes do not), settle in the Netherlands. Diseases, which are currently not spread by mosquitoes in the Netherlands, pose additional health risks (also see *paragraph 3.4*). The key expert scored this health effect at 3 ('expected sign or trend').

3.4. Vector-borne diseases

Opinions on the levels of precision for climate change effects through vector-bound diseases are divided, as indicated in *Figure 4*, also among the key experts. Native vector-borne diseases and incidents of non-native vector-borne diseases are scored at 'ambiguous sign or trend' (2) to 'order of magnitude' (4). Epidemics of non-native vector-borne diseases are scored at roughly 2-3. The scores of key experts on non-native diseases (both incidents and epidemics) are at 2-3, with one expert scoring 1, 2, 3 & 4 (indicated as a 0.25 vote for each).

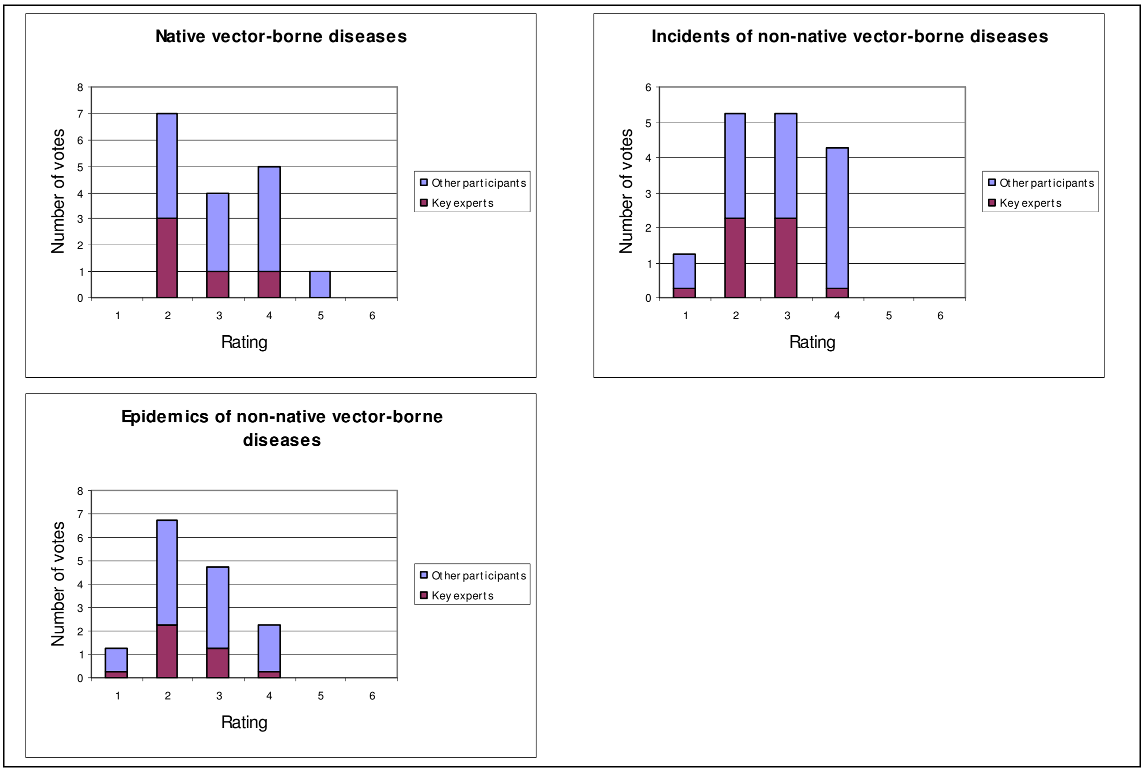


Figure 4. Scores for vector-borne diseases.

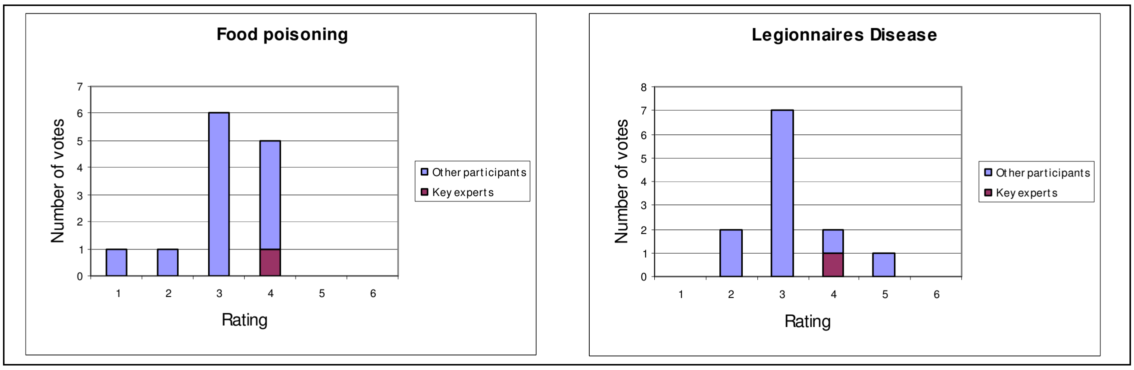
Regarding *native vector-borne diseases*, a key expert notes that Lyme is the only endemic vector-borne disease of any importance in the Netherlands. Arguments for a score of 2 indicate that Lyme has been discovered in the Netherlands only in the mid 1980's and that the short period of data makes conclusions on the effect of climate uncertain. There has been a strong increase (threefold in ten years time) in Lyme incidence. One key expert notes that he is strongly convinced that recent changes are multi-factorial and not solely or even mainly caused by climate shifts. Other factors include increased contact due to socio-economic changes and human intervention. Another respondent notes that it is unclear what the impact of climate change is, and that changes in temperature and moisture are not sufficient to explain the changes in incidence. Furthermore, vector-borne diseases are the result of extremely complex interactions. One key expert notes that it is highly unlikely that climate change has a unidirectional effect on these interactions. Nonetheless, respondents note that changes in temperature and moisture do affect cold-blooded animals like ticks and insects, and they refer to several publications suggesting that climate change may be expected to have an effect on Lyme. Specific uncertainties include the complexity of the Lyme disease transmission cycle and disease ecology, and the effect of climate change on these. Respondents scoring 3 refer to the same complexities. A key expert notes that data are presently being analysed, but that it is already clear that the activity season for ticks is becoming larger during warm winters. Respondents scoring 4 indicate that some data exists and that rough estimations could be made although the precise of role of climate change versus other effects is still difficult to assess. A respondent scoring 5 states that much data is available.

Arguments for *incidents of non-native vector-borne diseases* follow lines of reasoning similar to those above. Those arguing for a score of 2 indicate that there are many other factors that are likely more important than climate change, and that the complexity of the diseases make unidirectional impacts of climate change unlikely, despite the sensitivity of many of these biological processes to climatic conditions. Present increases in occurrence cannot be straightforwardly connected to climate change and simple lines of reasoning on the effects of temperature increases on the risk do not do justice to the complexity of the processes. Thus, the sign of any changes cannot be estimated even for a single disease, let alone for vector-borne diseases as a whole. An additional uncertainty is that basic information on vector-species is lacking. Those arguing for a score of 3 acknowledge these difficulties but suggest that there are some indications of increasing the risk, as conditions for incidental occurrences will improve for some diseases. Arguments for a score of 4 refer to opinions, available (although incomplete) data, and research from Maastricht University (but note that one of these researchers scored this effect at 1). One key expert scoring 1, 2, 3 & 4 indicated that the scoring is very variable from disease to disease. E.g., for some diseases, climate change effects on the risk may be ruled out or considered negligible, because other factors such as increased global travel and trade, socio-economic changes, increased contact, welfare and quality of the health care system dominate or limit the risk. For instance, the expert notes that for TBE, much of the observed shifts have been caused by socio-economic changes and increased contact.

The arguments for *epidemics of non-native vector-borne diseases* are largely the same as for incidents of such diseases. A few respondents however shifted to lower scores. One respondent who scored 4 for incidents and 3 for epidemics indicated that, for epidemics, data would need to be extrapolated from other countries (whereas for incidents, data was available yet incomplete). A respondent who scored 3 for incidents and 2 & 3 for epidemics noted that the actual spread of diseases into epidemics (rather than incidents) depends on even more variables; while epidemics of some diseases seem unlikely (trend estimate zero). Another respondent, scoring 2 in both cases, also placed more emphasis on the many other factors that play a role in the emergence of vector-borne diseases and spread into epidemics. Specific uncertainties include: incidence, severity and survival of vectors, complex disease ecology, interplay with other factors, and limited research for the Dutch situation.

3.5. Food- and water-borne diseases

The scores for health effects of climate change through food- and water-borne diseases, shown in *Figure 5*, are reasonably to very consistent. Food poisoning and contamination of swimming/recreation water are estimated at 'expected sign or trend' (3) to 'order of magnitude' (4). The single key expert scores both effects at 4. Legionnaires' disease is estimated at 3, although the key expert again scores 4.



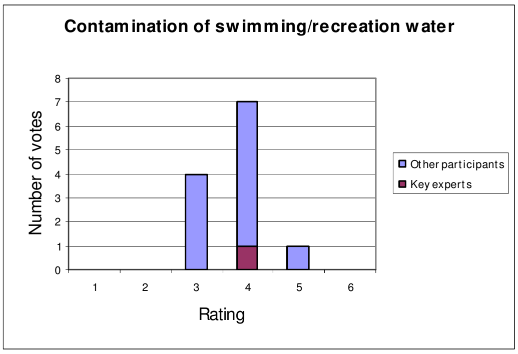


Figure 5. Scores for food- and water-borne diseases.

The arguments for a score of 4 for *food poisoning* indicate that many data (such as European time series analyses of these infections related to temperature) and models for impact assessment are available, particularly for Salmonella, and that rough estimations can be made. One respondent notes that the effect of generally warmer temperatures in specific countries/locations may be less clear. Arguments for a score of 3 agree to a potential effect of climate change, but note that it is unclear whether this will really result in an increased risk for the Dutch population (and to quantify this risk), because there are many other factors at play, such as good hygiene and use of refrigerators.

Some dissimilar arguments were also made. One respondent (scoring 2) notes that the problem is not specific for recent times, and another (scoring 4) states that the impact in the Netherlands will probably be nil as long as present standards of living persist. These arguments are repeated for Legionnaires disease, and the latter argument also for contamination of swimming/recreation water.

The argumentation for *Legionnaires' disease* was similar to that for food poisoning. The key expert (scored 4) noted that many data and models exist and that rough estimations could be made. The majority, scoring 3, noted that climate change might increase disease risk, but that this disease is related to warm water systems and that it is unclear what the relative impact of climate change will be, and that this depends on the water distribution infrastructure and adaptive capacity.

Also similarly, for *contamination of swimming/recreation water*, arguments for a score of 4 state that data and models exist and research on this topic is being performed in the Netherlands. Respondents arguing for a score of 3 state that the effect is clearly temperature related, but wonder whether it can be quantified, partly due to the fact that prevention of exposure is not always in time or successful (adaptation-related, but autonomous). Specific uncertainties include the nature, extent and tempo of impacts, presence of other factors that have similar effects, changes in the amount of water in urban areas, disease incidence, and the quantity of surface water in the summer season.

3.6. Air quality

In *Figure 6*, the health effects of climate change via interactions with air quality are scored. The individual scores diverge strongly, ranging from 'ambiguous sign or trend' (2) to 'bounds' (5). In other words, some participants suggest that it isn't clear if there will be negative or positive effects, while others pose that quantitative estimates can be made. It is notable that the key experts score higher (4-5) than the generalists on this topic (mostly 2-3).

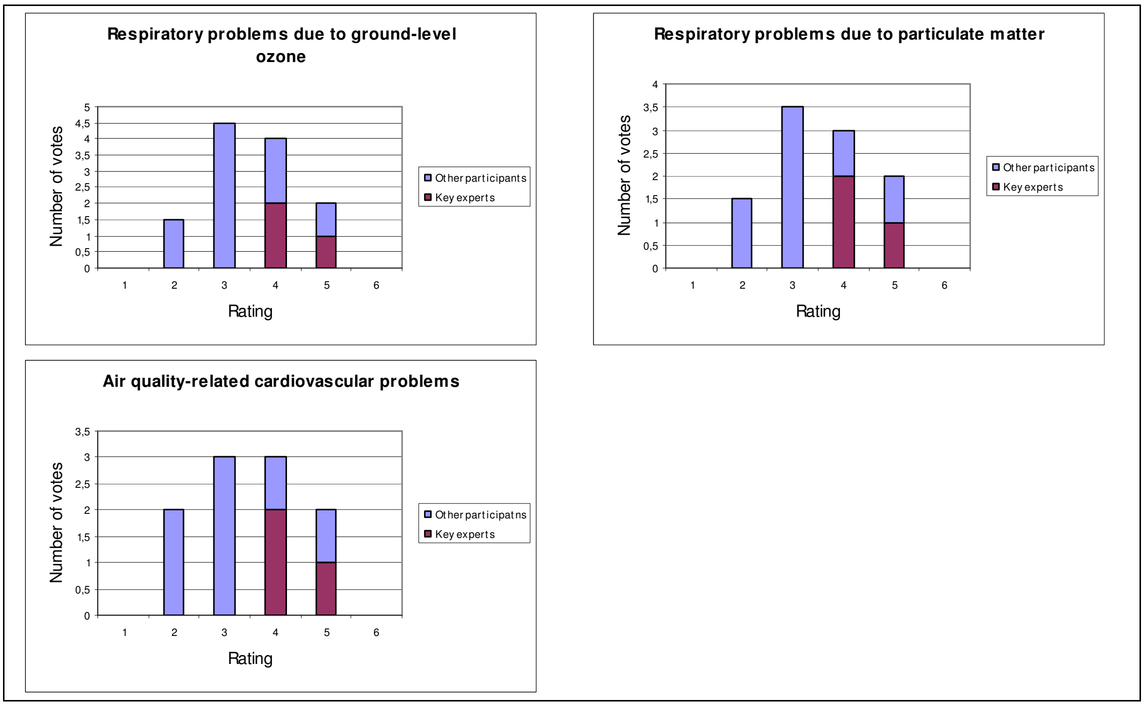


Figure 6. Scores for air quality-related health effects.

The respondents provide the same arguments for each of the three topics in air quality: *respiratory problems due to ground-level ozone*, *respiratory problems due to particulate matter*, and *air quality-related cardiovascular problems*. Arguments for a score of 4 stated that many data and models are available and much is known about the exposure-effect relationship. However, it is difficult to assess the effect of climate change on future concentrations of ozone, particulate matter and other pollutants, and the tempo of changes in these concentrations. Concentrations will be highly dependent on specific local conditions and changes therein (e.g. weather and wind patterns). Population vulnerability is temperature dependent and may also change. One respondent simply believed that, given the present standard of living, effects for the Netherlands would be minor. Arguments for lower scores (2, 2&3, and 3) agreed that the effect was temperature related, and that cause-effect relationships were known, but doubted that quantitative estimates could be made. For ozone, one respondent (scoring 3) noted that the risk of ozone smog might increase due to expected increases in the number of tropical days, but that this also depends on future changes in concentrations of ozone precursors. Another suggested that there are countervailing effects as well. A respondent scoring 2 & 3 for each of the effects stated that we do not know the time-integrated sign of change[5] of each of the substances (O_3, PM, NO_x). Specific uncertainties include the nature, extent and tempo of impacts, and the presence of other factors that affect these health issues, such as changes in emissions.

3.7. Flooding and storm

For most of the health effects in the category flooding and storm, scores are somewhat divided. The scores for flood-related mortality are particularly broad (2-5). The two key experts' scores are at the upper end of that range (scores 4-5) however. Flood-related infectious diseases and respiratory problems scored at 2-3 (for the latter: key expert scores are at 3-4), flood-related exposure to dangerous substances and contaminants at 2-4, and flood-related mental problems consistently at 3.

[5] E.g., changes in winter may be opposite to those in summer.

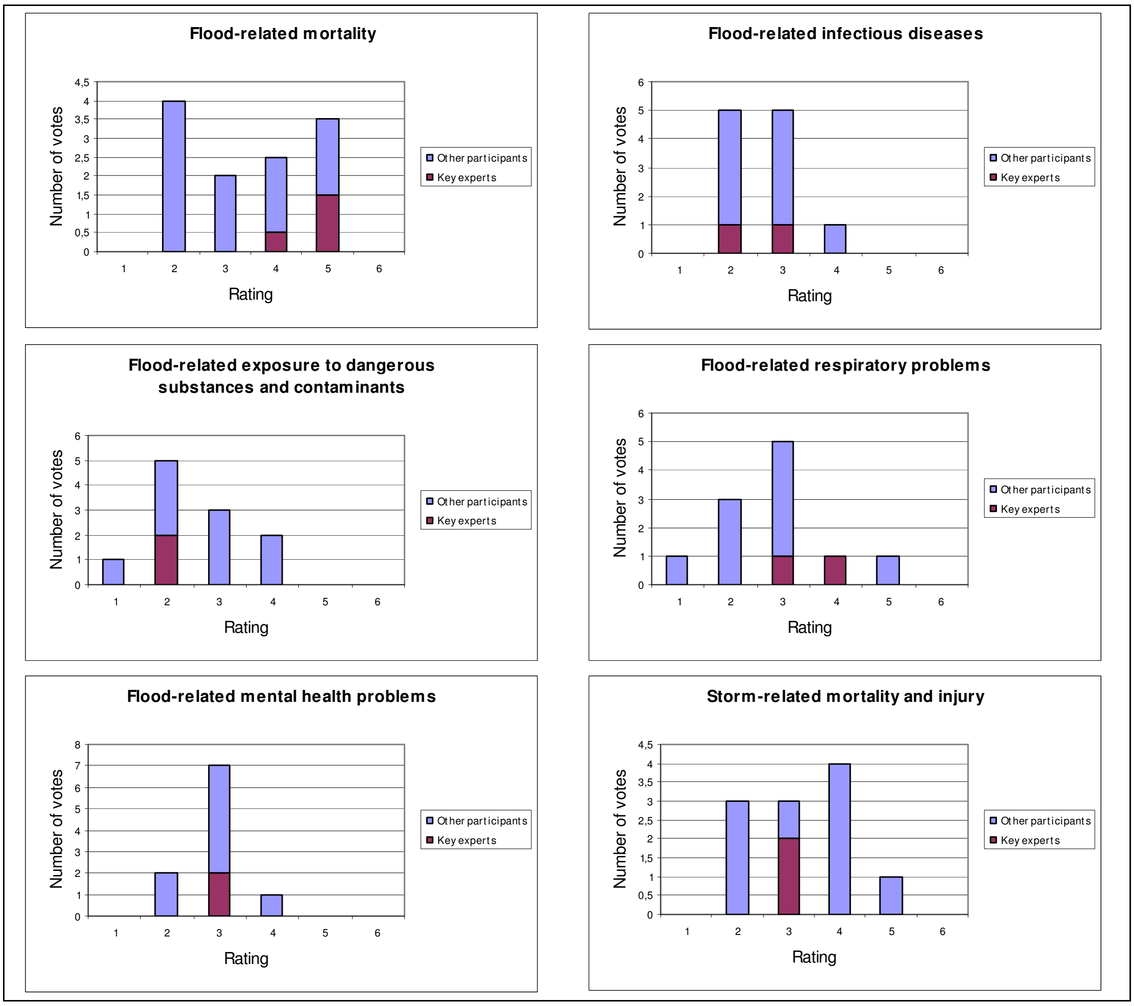


Figure 7. Scores for health effects related to flooding and storm.

Regarding *flood-related mortality*, the key expert and other respondents who suggested that 'bounds' (5) could be assessed, noted that many data and models are available and that we have sufficient experience to rate the risk. Another key expert rated 4 & 5, indicating that scenario-based estimations of casualties could be made, but suggested that such estimations would depend on a "daisy-chain of assumptions" and less quantifiable variables, thus placing them in between order of magnitude and bound estimates. A respondent who scored 4 indicated that effects are expected to remain low due to good evacuation infrastructure. It also depends on climate change adaptation related to flood risks, which is already ongoing[6]. A respondent who scored 2 suggested that we don't have records including health problems due to flood changes caused by climate change, and that flood intensity depends on many non-climatic aspects, which likely dominate climate change. The respondent repeated this score plus arguments for all other flood- and storm-related effects.

On *flood-related infectious diseases*, arguments for a score of 3 indicated that only few data (some from abroad) and models exist, but that there is a good chance on sewage overflows during floods, which would increase disease risk. Respondents who scored 2 indicated that there is no knowledge for the Netherlands, only circumstantial evidence from disasters abroad, particularly developing countries. Whether infections would take place in the Netherlands would remain to be seen; this also depends on the effectiveness of emergency

[6] This adaptation argument relates to water management, rather than health policy. It could be considered as autonomous or non-autonomous, and thus excluded or included in the assessment, depending on whether the arguments should inform health policy or climate adaptation in general.

management and the health care system. Assessing climate change effects hereon would be even more difficult.

Similar arguments are put forth for *flood-related exposure to dangerous substances and contaminants*. The arguments seem to focus on a score of 2, indicating that while the risk of chemical spills and sewage overflows might increase, there is a substantial lack of data and knowledge. It remains to be seen whether any effects would occur in the Netherlands. No arguments are put forth for decreases in this risk, which seems to indicate that the risks as assessed by respondents will be ‘zero or increasing’ (not ‘decreasing or increasing’).

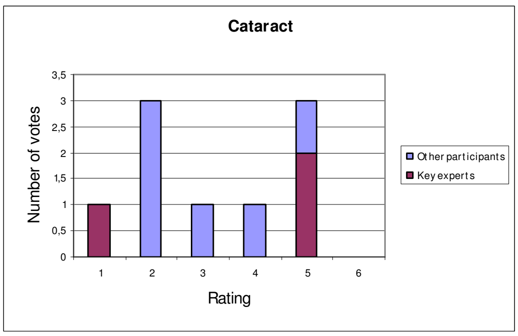
On *flood-related respiratory problems*, arguments for a score of 3 indicate that such effects have been shown in other countries and that dampness in homes after flooding is known to increase respiratory problems (due to moulds). An increase in the health risk can be expected, but quantification is difficult, e.g. because the translation of increased flooding risks to additional home dampness and effects in the Netherlands is difficult. Arguments for a score of 2 again point to lack of records, circumstantial evidence and non-climatic factors. The key expert who scored 4 indicated that, while there is a substantial lack of data, estimations on current dampness situations in homes exist.

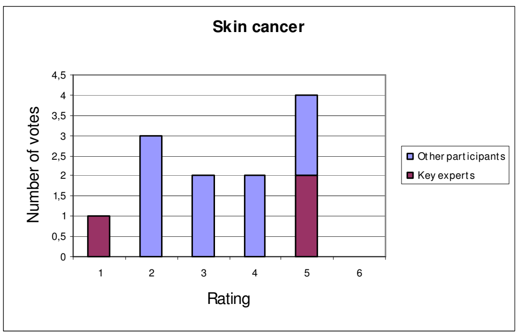
Regarding *flood-related mental health problems*, arguments for a score of 3 indicate that studies have shown mental health problems following floods and even evacuations in the past. These effects could be greater than the combined physical symptoms. However, respondents maintain, there is not enough data to make any estimates for future situations. An argument for score 4 was that data is available from other, comparable disasters.

Arguments for a score of 3 for *storm-related mortality and injury* state that climate change may have an effect on storms, e.g. counter the present declining trend in the number of storms, but that expected changes are relatively small and highly uncertain. Effects on mortality and injury risks might be expected, but there is a substantial lack of data on which to base projections of the health impacts of these small changes. A respondent scoring 2 states that it is still unclear whether climate change will increase or decrease the frequency and intensity of storms. Another mentions again a lack of records and presence of many non-climatic factors that may dominate the effects of climate change. A respondent scoring 4 notes that there is only circumstantial evidence, but also more evidence from other disasters, and a respondent scoring 5 notes that data is available that can be extrapolated.

3.8. UV

The respondents’ opinions on UV-related health effects due to climate change strongly diverge, ranging from ‘effective ignorance’ (1) to ‘bounds’ (5). There appear to be two peaks in the frequency distributions of each health effect; some respondents score the effects consistently very high, while others score them very low. This split is present among the key experts as well. This could mean one (or more) of several things: (a) there are several schools of thought, (b) the question has been interpreted in different ways, or (c) respondents lack sufficient information to properly score this theme.





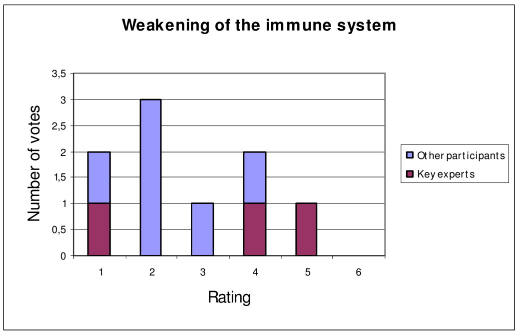


Figure 8. Scores for UV-related health effects.

Arguments for *cataract* and *skin cancer* are very similar and can be divided into two internally consistent lines of reasoning. Respondents who score the effects low indicate that they assume that the question does not deal with ozone depletion (by CFCs), but on the effects of climate change on ozone. There are complicated interactions between climate change and ozone depletion that could, for instance, hamper the recovery of the ozone layer. Furthermore, there are effects on the exposure to UV radiation via the effects of climate change on cloud cover and on behaviour (e.g., more time spent outside due to warmer temperatures). These effects are very uncertain and depend on many other factors. Arguments for high scores posit that much data is available from countries with a present-day climate that is similar to that which the Netherlands would be expected to have in the future. Good models are available to make impact assessments, based on projected exposures. The difference between the two group appears to be due to the presence of two schools of thought. The first group points to the complicated interactions between climate and ozone (scores low). The second group of respondents extrapolates exposure from warmer countries and points to the high quality of models that translate these into health impacts (scores high). The most important uncertainties seem to relate to how ozone concentrations and UV exposure will change due to climate change. When exposure is known, effects can be calculated.

For weakening of the immune system, respondents use many of the same arguments as for cataract and skin cancer. However, a respondent scoring 2 adds that the effects of UV radiation on the immune system are uncertain. A respondent scoring 4 notes that there are indications but the nature, extent and tempo of effects are largely unknown.

3.9. Other

One respondent suggested that *societal disruption* of societal structures, possibly elsewhere, would have important consequences for health in the Netherlands. In his view, these presented the greatest risk. Important uncertainties herein relate to economical development and governance structures.

3.10. Overview

Table 3 and *Figure 9* summarise the scores of respondents on the individual health effects, expressed in the interquartile range (the range in which 25-75% of the individual scores are located; i.e. 25% of the scores are lower, and 25% are higher) and the median estimate.

The scores for most health effects range from 2-3 ('ambiguous sign or trend' to 'expected sign or trend') or 3-4 ('expected sign or trend' to 'order of magnitude'). For most effects, the median score is 3. High scoring effects (median: 4) are: heat-related mortality, cold-related mortality, the oak processionary caterpillar, and contamination of recreation water. Shortages of drinking water, the three air quality-related effects, flood-related mortality, and UV-related skin cancer score relatively high as well (median: 3.5). Very low scoring effects (median: 2) are: allergic eczema, flood-related exposure to dangerous substances, and UV-related weakening of the immune system. Wasps and epidemics of non-endemic vector-borne diseases score low as well (median: 2.5).

Consensus on the oak processionary caterpillar (median: 4) and flood-related mental health problems is notably high (width of the 25-75% interval: 0). Effects on which there is notably low consensus include flood-related mortality (width: 2,625) and UV-related cataract and skin cancer (both cases width: 3).

Table 3. Overview of scores of health effects (not weighted).

	Effect:	Median:	25%	75%	Δ25-75%
1	Temperature: Heat-related mortality	4	4	5	1
2	Temperature: Heat-related cardiovascular problems	3	3	4	1
3	Temperature: Heat-related respiratory problems	3	3	4	1
4	Temperature: Heat-related stress and sleep disturbance	3	3	4	1
5	Temperature: Cold-related mortality	4	3	4	1
6	Temperature: Cold-related diseases	3	3	4	1
7	Temperature: Drought-related exposure to contaminants	3	2	3	1
8	Temperature: Shortages of drinking water	3.5	2.75	4	1.25
9	Temperature: Dehydration	3	2	3.75	1.75
10	Allergies: Asthma	3	2	3	1
11	Allergies: Allergic eczema	2	2	3	1
12	Allergies: Hay fever: duration of pollen season	3	3	4	1
13	Allergies: Hay fever: pollen types, abundance and allergenicity	3	3	3.5	0.5
14	Pests: Wasps	2.5	2	3.25	1.25
15	Pests: Oak processionary caterpillar	4	4	4	0
16	Vector-borne: Native vector-borne diseases	3	2	4	2
17	Vector-borne: Incidents of non-native vector-borne diseases	3	2	3.25	1.25
18	Vector-borne: Epidemics of non-native vector-borne diseases	2.5	2	3	1
19	Food/water-borne: Food poisoning	3	3	4	1
20	Food/water-borne: Legionnaires Disease	3	3	3.25	0.25
21	Food/water-borne: Contamination of swimming/recreation water	4	3	4	1
22	Air quality: Respiratory problems due to ground-level ozone	3.5	3	4	1
23	Air quality: Respiratory problems due to particulate matter	3.5	3	4	1
24	Air quality: Air quality-related cardiovascular problems	3.5	3	4	1
25	Flood/storm: Flood-related mortality	3.5	2	4.625	2.625
26	Flood/storm: Flood-related infectious diseases	3	2	3	1
27	Flood/storm: Flood-related exposure to dangerous substances and contaminants	2	2	3	1
28	Flood/storm: Flood-related respiratory problems	3	2	3	1
29	Flood/storm: Flood-related mental health problems	3	3	3	0
30	Flood/storm: Storm-related mortality and injury	3	2.5	4	1.5

31	UV: Cataract	3	2	5	3
32	UV: Skin cancer	3.5	2	5	3
33	UV: Weakening of the immune system	2	2	4	2

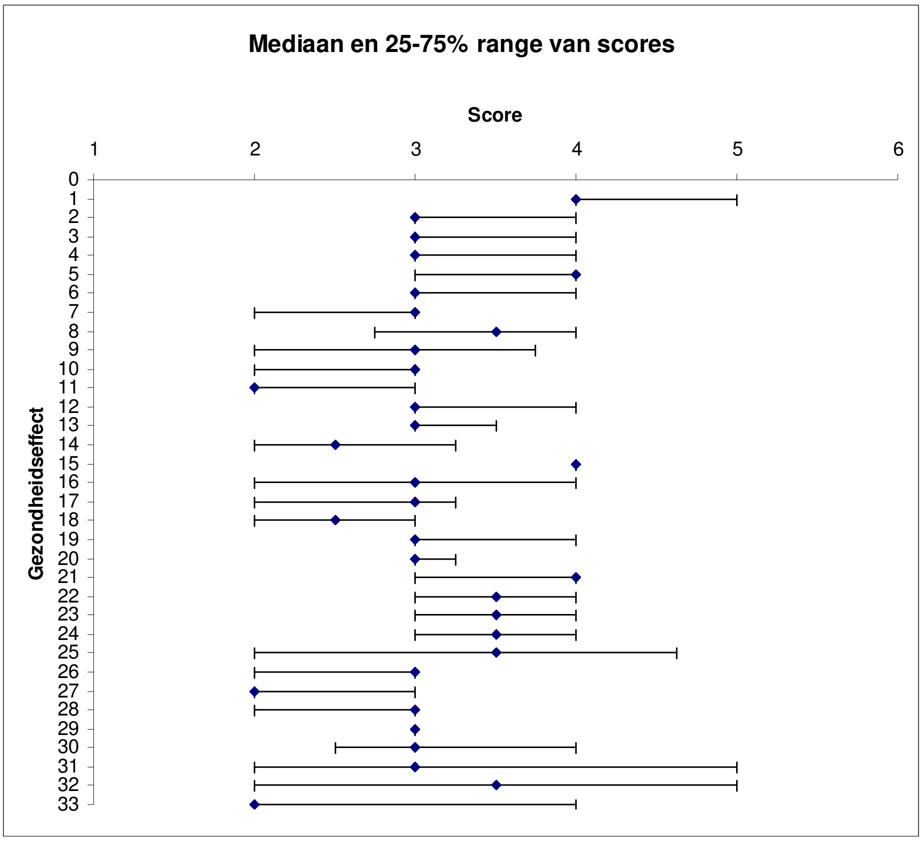


Figure 9. Overview of scores of health effects (not weighted). The dot indicates the median of the individual scores; the error bar indicates the 25-75% range of the scores.

As some experts may have more expertise to assess a health effect than other experts, the summarized scores can be weighted according to the self-indicated expertise. Weighted scores may provide a better picture of the level of uncertainty. In addition, they can provide an interesting test of the sensitivity of the results to differences in expertise. In *Table 4* and *Figure 10* below, the scores of key experts on specific effects have been given twice as much weight (i.e. are double-counted).

As listed in the right-most columns of *Table 4*, the changes in scores are minor, but some things can be noted. The medians of flood-related mortality and the air quality-related and UV-related effects shift 0.5 points. Thus, flood-related mortality, air quality-related respiratory effects (ozone, PM) and cardiovascular effects, and UV-related skin cancer shift from ‘relatively high’ to ‘high’ scoring (median: 4). In addition, consensus on the effect ‘hay fever: pollen types, abundance and allergenicity’ turns very high (width 25-75% interval: 0).

Table 4.Overview of scores of health effects (weighted).

					Difference with unweighted scores:		
Effect:	**Median:**	**25%**	**75%**	**Δ 25-75%**	**Median:**	**25%**	**75%**
1	4	4	5	1	0	0	0
2	3	3	4	1	0	0	0
3	3	3	4	1	0	0	0
4	3	3	4	1	0	0	0
5	4	3	4	1	0	0	0
6	3	3	4	1	0	0	0
7	3	2	3	1	0	0	0

8	3.5	2.25	4	1.75		0	-0.5	0
9	3	2	4	2		0	0	0.25
10	3	2	3	1		0	0	0
11	2	2	3	1		0	0	0
12	3	3	3.5	0.5		0	0	-0.5
13	3	3	3	0		0	0	-0.5
14	2.5	2	3	1		0	0	-0.25
15	4	4	4	0		0	0	0
16	3	2	4	2		0	0	0
17	3	2	3	1		0	0	-0.25
18	2.5	2	3	1		0	0	0
19	3	3	4	1		0	0	0
20	3	3	4	1		0	0	0.75
21	4	3	4	1		0	0	0
22	4	3	4	1		0.5	0	0
23	4	3	4	1		0.5	0	0
24	4	3	4	1		0.5	0	0
25	4	2.25	4.875	2.625		0.5	0.25	0.25
26	3	2	3	1		0	0	0
27	2	2	3	1		0	0	0
28	3	2	3	1		0	0	0
29	3	3	3	0		0	0	0
30	3	3	4	1		0	0.5	0
31	3.5	2	5	3		0.5	0	0
32	4	2	5	3		0.5	0	0
33	2.5	1.75	4	2.25		0.5	-0.25	0

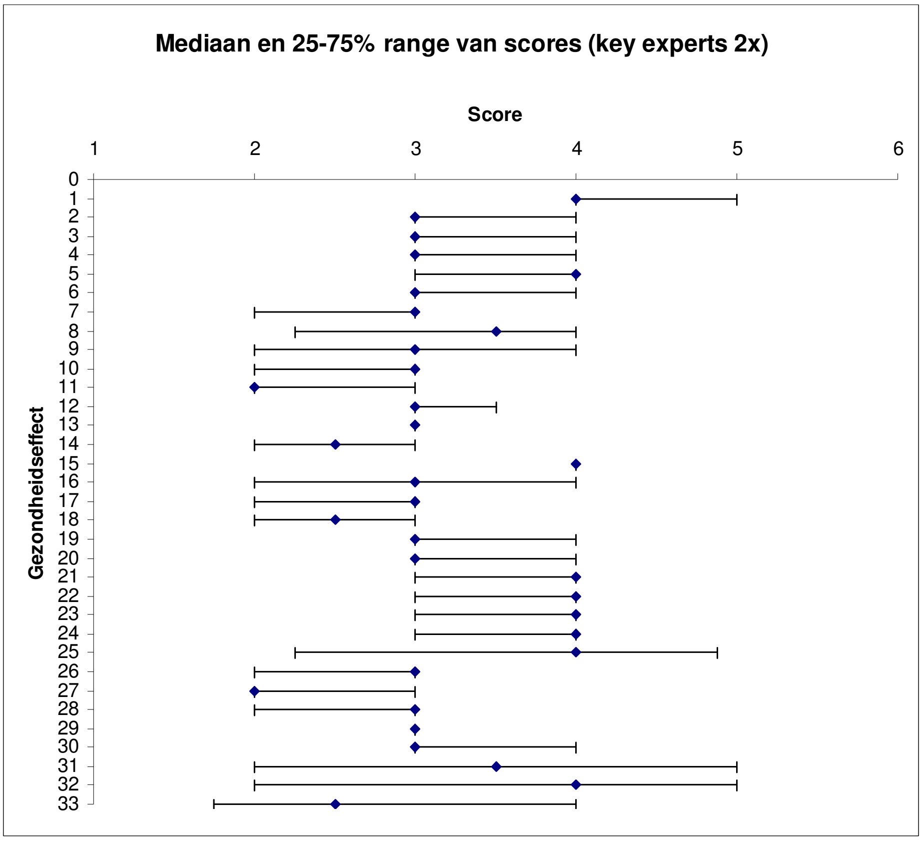


Figure 10. Overview of scores of health effects (weighted).

4. Uncertainty and adaptation

This chapter will detail which potential health effects respondents consider relevant for Dutch climate change adaptation policy, and the policy options and strategies that could be useful considering the uncertainties.

4.1. Relevance of health effects for adaptation policy

Respondents were asked to indicate and rank the five health effects they considered most ‘relevant’ for Dutch climate adaptation policy in view of public health. They were asked to interpret this in a broad way (allowing for multiple lines of reasoning), taking into account the possible magnitude of the health impact, economic impact, public and political perception, and the availability of options for adaptation and control. Respondents’ arguments (practically all by adaptation, policy and health theme experts) are discussed below.

A broad spectrum of health effects was selected as ‘most relevant for climate change adaptation in the Netherlands in view of health’. See *Table 5* and *Figure 11*. Heat-related mortality is by far the most often selected effect. Incidents of non-endemic vector-borne diseases is a second high-scoring effect. Other effects that score relatively high include: epidemics of non-endemic vector-borne diseases, hay fever (duration of pollen season and pollen types/abundance/allergenicity), heat-related cardiovascular and respiratory problems, endemic vector-borne diseases, and flood-related mortality. In general, it is notable that the (sub)themes ‘temperature: heat-related’ and ‘vector-borne diseases’ were judged to be the most relevant themes for climate change adaptation in the health sector in the Netherlands.

The scoring exercise was completed by 16 respondents, plus one who prioritised the health themes rather than the specific effects (on the argument that health impacts of various themes gained relevance due to the combination of specific effects)[7]. He also suggested that respondents would likely indicate their own field(s) of study/work as the most important. Scores were cross-checked for this possible bias, but it did not appear to be prominent (scorings in two cases seemed clearly correlated with the expert’s field, another possibly).

Table 5. Relevance of health effects for Dutch climate adaptation policy. Column ‘relevance’ indicates the number of times an effect has been selected as 1st, 2nd, etc. most important. Column ‘points’ indicates the point total, where every score of 1st is 5 points, 2nd is 4 points, etc.

		Relevance					
Effect:		**1**	**2**	**3**	**4**	**5**	**Points:**
1	Temperature: Heat-related mortality	6	2	1			41
2	Temperature: Heat-related cardiovascular problems	1		2			11
3	Temperature: Heat-related respiratory problems	1	1		1		11
4	Temperature: Heat-related stress and sleep disturbance	1					5
5	Temperature: Cold-related mortality						
6	Temperature: Cold-related diseases						
7	Temperature: Drought-related exposure to contaminants						
8	Temperature: Shortages of drinking water					1	1
9	Temperature: Dehydration		2				8
10	Allergies: Asthma			1		1	4
11	Allergies: Allergic eczema						
12	Allergies: Hay fever: duration of pollen season		2		1	2	12
13	Allergies: Hay fever: pollen types, abundance and allergenicity		2	1			11
14	Pests: Wasps						

[7] This respondent scored the health themes: 1. allergies, 2. vector-borne, 3. temperature, 4. food/water-borne, 5. pests. These are not included in *Table 5*.

15	Pests: Oak processionary caterpillar		1				4
16	Vector-borne: Native vector-borne diseases	1	1			1	10
17	Vector-borne: Incidents of non-native vector-borne diseases	1	2	2	1		21
18	Vector-borne: Epidemics of non-native vector-borne diseases	2			2		14
19	Food/water-borne: Food poisoning				1		2
20	Food/water-borne: Legionnaires Disease					1	1
21	Food/water-borne: Contamination of swimming/recreation water				1	2	4
22	Air quality: Respiratory problems due to ground-level ozone			1	2		7
23	Air quality: Respiratory problems due to particulate matter						
24	Air quality: Air quality-related cardiovascular problems				1	1	3
25	Flood/storm: Flood-related mortality	1		1	1		10
26	Flood/storm: Flood-related infectious diseases						
27	Flood/storm: Flood-related exposure to dangerous substances and contaminants			1			3
28	Flood/storm: Flood-related respiratory problems						
29	Flood/storm: Flood-related mental health problems		1			2	6
30	Flood/storm: Storm-related mortality and injury						
31	UV: Cataract						
32	UV: Skin cancer			2			6
33	UV: Weakening of the immune system						
34	OTHER: societal disruption elsewhere	1					5

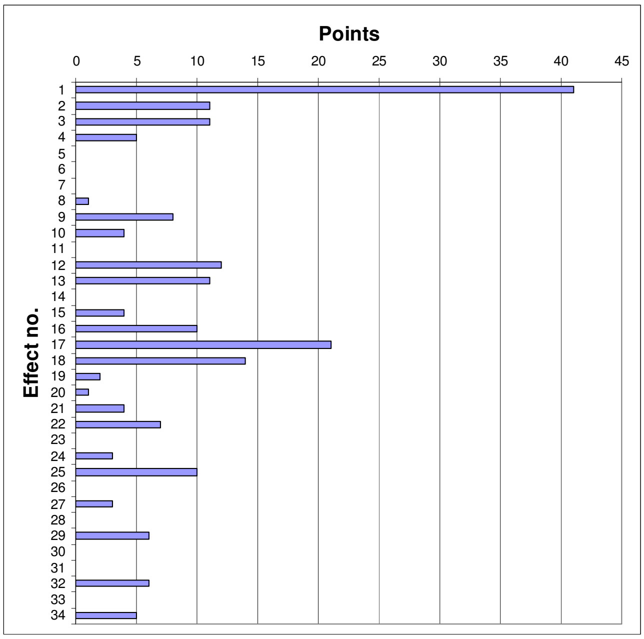


Figure 11. Point totals for relevance of health effects for Dutch climate adaptation policy.

For analytical purposes, the relevance and level of precision scores of health effects can be plotted in a single graph; see *Figure 12*. However, considering the fact that the relevance scores depend on a relatively small number of participants and votes, using the actual scores would lead to an unwarranted level of resolution. Therefore, the relevance scores have been converted to four 'classes' of relevance. Class I includes effects that none selected as one of the most relevant; 0 points. These can be considered as having a limited relevance (at least comparative to other health effects). Class II includes effects that were selected by only few participants; 1-10 points (can be achieved by as little as two votes). Class III includes effects that were selected relatively often; 11-20 points. Class IV includes effects which have been selected often and with high scores; 21 or more points. These can be considered as highly relevant. It is notable that the two effects that respondents consider most relevant, heat-related mortality and incidents of non-endemic vector-borne diseases, differ considerably in level of precision; 4-5 (order of magnitude – bounds) and 2-3 (ambiguous sign/trend – expected sign/trend) respectively.

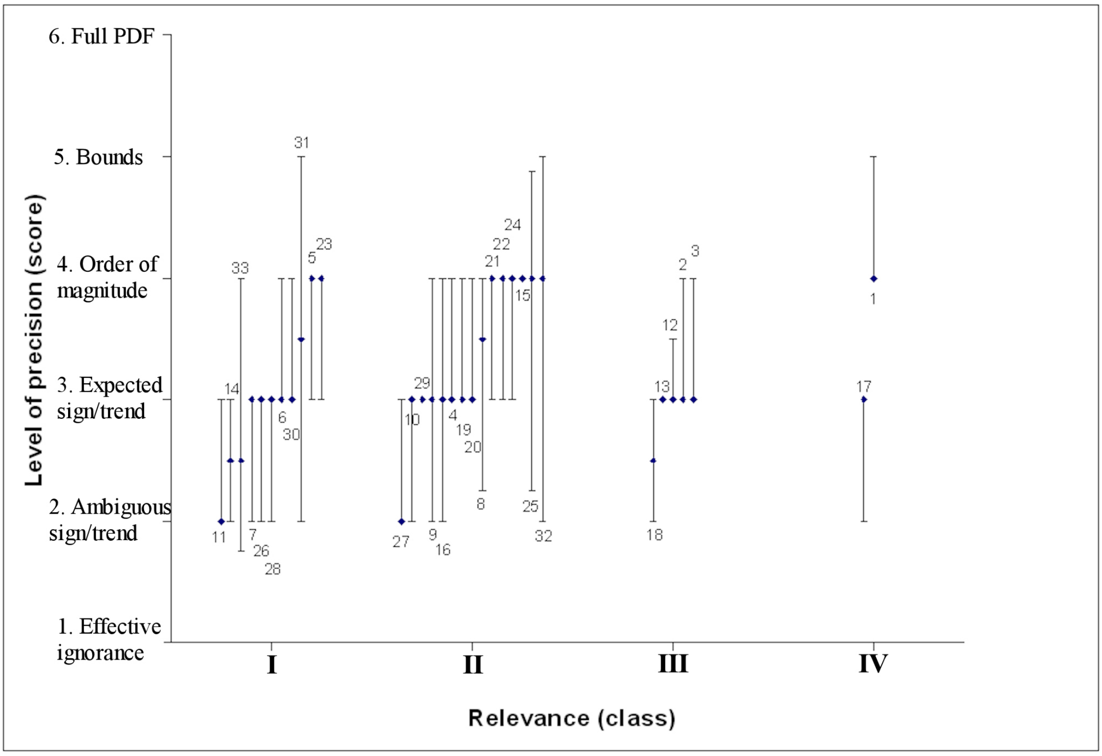


Figure 12. Diagnostic diagram of health effects. Class ratings range from limited to high relevance, indicating: I: 0 points, II: 1-10 points, III: 11-20 points, IV: 21 or more points. For the level of precision, the dot indicates the median score, the error bar the 25-75% interval.

Temperature

A consistent line of argument in respondents' reasoning why *heat-related mortality* is most relevant for adaptation is that homes for the elderly, nursing homes, houses, and city/town planning in the Netherlands are not adapted at all to higher temperatures (and changes in high temperatures). A participant makes this argument for Europe as a whole. Other arguments include: political interest, public perception, stress on the health care system, a current lack of interest in the topic by the health care sector, and many people are at risk and potentially many victims in a short period of time. One expert notes that the high relevance score applies to the entire topic of heat-related mortality and disease.

For *heat-related cardiovascular and respiratory problems*, respondents note that the effects could be substantial, and refer to many risk factors that could enhance the impact (traffic and city design and related air quality problems, and high incidence of obesity, cardiovascular disease and diabetes).

For *dehydration*, a respondent notes again that homes for the elderly are not adapted. For heat-related stress and sleep disturbance notes that people would be tired during work/school (i.e. resulting in economic impacts).

Allergy

For *asthma*, respondents argue that the number of people already affected is already large, and rising, and is causing a considerable health burden. Changes herein due to climate change would add to this, resulting in high economic impacts (disease prevention, chronic disease treatment). For *hay fever (duration of pollen season)* a similar argument is made: a large number of people will be affected, and it could result in a loss of working days (more generally: decreased worker productivity; also an economic impact). For *hay fever (pollen types/abundance/allergenicity)*, it was noted that effects could be substantial and difficult to adapt to.

Vector-borne diseases
For *endemic vector-borne diseases*, a respondent notes that a huge increase in disease risk has been observed in the past fifteen years, and that the costs for treatment of the chronic condition are high, as is the possible disease burden (e.g. due to neurological effects).

For *incidents of non-endemic diseases*, respondents note that effects could be substantial and difficult to adapt to, and that incidents can be difficult to recognise and could result in public unrest. Similarly, for *epidemics of non-endemic diseases*, respondents stress a high potential health and economic impact, the link with public risk perception ('fright factors'), and stress on the health care system.

Food- and water-borne diseases
A respondent notes that the effects of *contamination of swimming/recreation water* could be substantial and difficult to adapt to. Another indicates that it is relevant because of the large amount of water in the Netherlands and recreational habits.

Air quality
Considering air quality-related health effects, one respondent notes for *respiratory problems due to ground-level ozone* that air pollution is already a considerable health problem and that climate change might add to this. Another indicates for *air quality-related cardiovascular problems* that effects could be substantial and difficult to adapt to.

Flooding and storm
Respondents who consider *flood-related mortality* to be relevant, indicate that flooding is a politically sensitive and culturally important topic for the Netherlands. The risk has a wide spatial extent and large potential impacts (e.g. spatial scale, societal 'signal value' of casualties). *Flood-related mental problems* are an underlying stress for populations in hazard areas and an under-recognised issue while effects have been reported even during evacuations (rather than only in case of actual flooding). *Flood-related exposure to dangerous substances and contaminants* could be relevant because there could be widespread exposure and it would be highly politically sensitive due to questions of blame.

UV
UV-related skin cancer could be relevant because of the cultural habits of sun bathing.

4.2. Uncertainty and options for adaptation

For health effects which respondents considered the most relevant, they were asked to indicate which policy options/strategies they considered to be particularly well-capable of dealing with the uncertainties associated with the effect – and which options/strategies would be very vulnerable to them. The answers will be discussed per health theme. No answers were provided for 'pests'. A total of 34 answers were provided, the majority (28) of which were made by adaptation and health theme experts.

Temperature
Respondents suggested a diverse set of options for *heat-related mortality*, which would be capable of dealing with the uncertainties associated with this health effect. A number of respondents noted information supply and education as important, particularly aimed at vulnerable groups (e.g. the elderly) and other risk groups and caretakers of such groups. In any warning system for heat, responsibilities of relevant actors should be clear and the system should be based on scientific findings regarding risk conditions and options for adaptation. Respondents mention the need for action plans and contingency plans on what to do in case of heat several times. They refer to the Dutch National Heat Plan (VWS, 2007) in several

instances. Aside from these relatively mild, 'soft' strategies, more extensive and physical measures are mentioned as well. Planners could take heat into account in urban/area planning, e.g. by providing parks, open water, wind-corridors, et cetera. These could limit the effects of the urban heat island. Heat could also be (better) taken into consideration in building regulations, design and construction, for instance when developing homes for the elderly. One respondent also suggests further efforts on climate modelling.

Regarding *heat-related cardiovascular and respiratory problems*, several options mentioned above are suggested again; for instance the National Heat Plan and area planning. Other suggestions include monitoring and surveillance, 'early warning', data collection, and development of models for scenario-analysis and impact assessment (i.e. more research). In addition, a respondent notes that limiting/preventing summer smog is important. In other words, policy on another issue (air quality) could (be enhanced to) produce co-benefits for climate & health. For dehydration, respondents refer again to the Heat Plan.

Respondents did not suggest any options that were specifically vulnerable to the uncertainties associated with the theme of temperature-related effects.

Allergy

Regarding the theme of allergy, respondents suggested uncertainty-robust options for *asthma* and *hay fever (duration of pollen season, and pollen types/abundance/allergenicity)*. Information supply and warning-systems – and related to this: better timing of medication intake – for hay fever patients are indicated as important by many participants. Furthermore, the allergenicity of the pollen that plants produce should be taken into account when selecting plants for public green spaces and nature management. Monitoring and surveillance, data collection, and development of models is useful as well. Medicine production and increases herein are mentioned as well[8]. Respondents did not suggest any options that were specifically vulnerable to the uncertainties associated with this health theme.

Vector-borne diseases

Limiting the number of tick-bites and quick removal of ticks is important for limiting the consequences of climate change regarding *endemic vector-borne diseases*. Monitoring- and warning-systems are important as well. However, one respondent notes, risk communication and education are not always successful in reducing risky behaviour. Particular risk groups are people participating in outdoor recreation and rangers.

For *incidents of non-endemic vector-borne diseases*, respondents suggest monitoring and surveillance to be important and uncertainty-robust. One respondent notes that education of health professionals on the topic of climate change is useful, as is the creation of flexible and generic action/contingency plans. Another again suggests early warning, data collection and model development. Furthermore, general hygiene and production of vaccines and medicines could be enhanced. Conversely, one participant indicates that the creation of large stockpiles of vaccines entails a large risk of overinvestment and is therefore a strategy that is vulnerable to uncertainty. A strategy such as pre-emptive vaccination could also entail the risk of negative health impacts or other side-effects (in addition to overinvestment risk). Action/contingency plans that are very (overly) specific for certain diseases or scenarios/transmission routes would be very vulnerable to surprises.

Regarding *epidemics of non-endemic vector-borne diseases*, respondents note once more that monitoring and surveillance are uncertainty-robust. One respondent also suggests performing literature assessments and surveys on what is happening in other parts of the world regarding vector-borne diseases. Another indicates 'early response' and vaccination as possible options.

[8] Note that medicine production can be considered relatively no-regret in the case of hay fever, as it is already prevalent.

Food- and water-borne diseases
Information supply, monitoring/surveillance, early warning and data collection and model development are mentioned as options that are well-capable of dealing with the uncertainties. Other suggestions include good distribution of surface water, keeping in mind the link with urban design, and improving health care in general.

Air-quality
The effects of climate change on health via air quality can be reduced by measures which limit air pollution. Patients with respiratory conditions are a risk group. One respondent mentions once again: monitoring/surveillance, early warning, data collection and model development, keeping in mind the link with urban design, and better health care.

Flooding and storm
Flood-related mortality can be limited by improving water safety in general, via a combination of adaptation approaches that limit the probability and consequences of flooding. Good evacuation and monitoring strategies are also important. The two respondents who comment on this health effect both note that 'hard engineering' approaches are very vulnerable to uncertainties. They make risks more unpredictable and increase the vulnerability in case something does happen.

Flood-related mental health problems can be reduced by keeping this issue in mind in disaster response and recovery plans, including in evacuation plans. It is also important to educate and train rescue workers, general practitioners and mental health professionals regarding this health aspect of flooding.

UV
Good information supply is suggested as a strategy that is well-capable of dealing with the uncertainties, for the effects of climate change via ultraviolet radiation.

Other
One respondent suggested that *societal disruption* of societal structures, possibly elsewhere, would have important consequences for health in the Netherlands He noted that present political trends all hamper adaptation and that societal change or transition is needed.

5. Conclusions

This chapter summarises the conclusions that can be drawn from this study. Starting point of our analysis is that our present state of knowledge on health impacts of climate change is characterized by huge knowledge gaps and deep uncertainties. In order to be fit for function, adaptation strategies need to take on board the nature of uncertainty of each anticipated health effect. Effects that can reliably be quantified could for instance be tackled with a predict-then-act approach whereas health effects where even the sign of the trend is unknown under a given climate scenario can better be tackled by a highly flexible resilience-based approach. Climate adaptation in the health sector should thus start with a good understanding of the uncertainties and limitations to our ability to quantify and predict each anticipated health impact. This study is a first attempt to map this systematically for the case of The Netherlands.

Based on literature study and expert consultations we drafted a gross-list of potential health effects of climate change for the Netherlands. For each item on the gross-list respondents were asked to estimate the ‘level of precision’ (on the scale presented in table 1) with which health risk estimates could be made given the present state of knowledge. They were also asked to indicate which of these potential effects are most relevant for Dutch climate adaptation, and which adaptation options are well-capable of dealing with the uncertainties associated with these effects.

Level of precision for health risk estimates: general conclusions

- For most potential health effects of climate change in the Netherlands, effects were indeed expected and their sign/trend could be indicated (respondents’ median estimate). However, quantification has been judged to be not yet possible for most effects. Individual scores for various health effects often ranged from ‘expected sign/trend can be indicated’ to ‘order of magnitude of the health risk can be indicated’, or from ‘sign/trend is ambiguous’ to ‘expected sign/trend can be indicated’.
- For some effects, quantitative estimates seemed within reach given the present state of knowledge. These include: heat-related mortality, cold-related mortality, the oak processionary caterpillar, contamination of recreation water, and air-quality related effects. Flood-related mortality and UV-related skin cancer and cataract score high as well, but individual estimates diverge considerably.
- For other effects, while some effect was expected, it may not (yet) be possible to indicate the direction of change. These include: allergic eczema, flood-related exposure to dangerous substances, and UV-related weakening of the immune system. Wasps and epidemics of non-endemic vector-borne diseases scored low as well.

Level of precision for health risk estimates: specific arguments

We summarize the main arguments provided by the respondents to justify the scores given.

- For heat-related mortality, a large body of literature exists, but several factors limit quantification: limited data for the Netherlands specifically, confounding/interacting factors, and uncertainties regarding response functions, future heat waves and biological mechanisms. Other heat-related effects scored lower because less data is available on the specific drivers.
- Scores and arguments for cold-related effects were similar, but some experts suggested a lower score, indicating that the effect could be either positive or negative depending on whether the difference between summer and winter temperature will increase and biological adaptation will take place.
- Allergies are highly multi-factorial and, while effects were expected, quantification of climate impacts did not seem possible.

- Temperature effects on wasps can be multi-directional; effects seemed plausible, but opinions on whether the sign/trend can be assessed differed. For the oak processionary caterpillar, the order of magnitude of climate effects could be assessed.
- Vector-borne diseases are highly complex and multi-factorial. Impact on some non-endemic diseases could be ruled out for the Netherlands. The effect on other diseases was seen as unclear even though climate is clearly an important factor.
- For food- and water-borne diseases, effects were expected and as models and data are available, rough indications of the impact were thought to be possible. However, factors such as available infrastructure, effectiveness of regulations, and standard of living complicate these estimates.
- For air quality, many data and models are available and quantitative estimates may be possible. However, the specific climatic impact on air quality depends on specific local conditions and there are countervailing effects, which complicates these estimates. Effects during winter are also less clear than those during summer.
- Many data and models are available for flood-related mortality. However, this also depends on many non-climatic factors, which are more difficult to assess. Effects were expected for flood-related diseases, contaminants, mental health, and respiratory problems, and storm-related effects, but lack of data prevents quantification.
- Two lines of reasoning were expressed for effects via UV radiation: (a) Models are available and effects can be calculated, given reliable estimates of exposure (score: bounds). (b) However, interaction between climate and ozone concentration and UV exposure are highly uncertain (score: ambiguous sign/trend).

Relevance for adaptation

- Respondents considered heat-related mortality and incidents of non-endemic vector-borne diseases to be the most relevant health effects for Dutch climate adaptation in view of health.
- These two effects had very different levels of precision: ‘order of magnitude’ to ‘bounds’ for heat-related mortality, and ‘ambiguous sign/trend’ to ‘expected sign/trend’ for incidents of non-endemic vector-borne diseases. Consequently, they may require different adaptation approaches (the answers on adaptation options do provide some hints in this direction).
- Other effects that respondents selected as most relevant include: heat-related cardiovascular and respiratory problems, hay fever (duration of pollen season, and changes in pollen types, abundance and allergenicity), and epidemics of non-endemic vector-borne diseases.

Uncertainty and adaptation options/strategies

- Adaptation options/strategies that were often suggested as well-capable of dealing with uncertainties include: monitoring and surveillance; education, information supply and (early-)warning systems (i.e. communication); data collection and model development (i.e. research); and improving health care and hygiene in general.
- Development of response and recovery mechanisms, such as action plans, contingency plans, evacuation and disaster plans, et cetera, was often mentioned as a useful option that would be well-capable of dealing with uncertainties. For vector-borne diseases, one respondent noted that these should be flexible or relatively generic. Overly specific plans would be vulnerable to surprise.
- For some effects, such as heat-related respiratory/cardiovascular problems and air quality and flooding/storm related effects, policy measures in other policy fields (air quality, water safety) were deemed useful under the uncertainties.
- For heat-related mortality, several more ‘hard’ physical measures and planning and judicial measures with relatively large implications for current practice were suggested. Heat could be taken into account in area planning and building regulations, design and construction. For vector-borne diseases and flood-related

mortality, some respondents warned against such hard and extensive measures, indicating that they could entail large risks of overinvestment and negative side-effects, or increase vulnerability.

Considering the level of uncertainty associated with the health effects of climate change, the scope for predict-and-prevent adaptation approaches seems very limited at present. Approaches that focus on enhancing the health system's capability of dealing with changes, uncertainties and surprises (for example by increasing resilience, flexibility, and adaptive capacity) are more suitable. For more quantifiable effects (e.g. heat-related mortality), it may be useful to explore the robustness of policy strategies under a range of plausible outcomes, at least in a qualitative/semi-quantitative way. For ambiguous yet highly relevant effects (e.g. non-endemic vector-borne diseases), precautionary measures could be considered, although flexibility and risks of overinvestment should be assessed.

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Acknowledgements

We would like to thank Leendert van Bree and Eva Kunseler for contributing to this study and providing comments as our contacts at PBL. We'd like to thank Maud Huynen for comments and for providing a list of Dutch experts who could be invited to take part in the survey. We'd like to thank Ides Boone and Franziska Matthies for providing suggestions for non-Dutch experts. The survey respondents (*Appendix A*) are thanked for their participation.

This project was commissioned and funded by the Netherlands Environmental Assessment Agency (PBL) and contributes to the PBL project "M/500078/01: Klimaatbeleid en Adaptatie".

Appendices

Appendix A. Participants

- Neil Adger (University of East Anglia, UK)
- Inez de Boer (The Netherlands Red Cross)
- Ides Boone (Veterinary and Agrochemical Research Centre, Belgium)
- Marieta Braks (National Institute for Public Health and the Environment (RIVM))
- Leendert van Bree (Netherlands Environmental Assessment Agency)
- Bram Bregman (Royal Netherlands Meteorological Institute (KNMI))
- Bert Brunekreef (Institute for Risk Assessment Sciences, Utrecht University)
- Hein Daanen (TNO; e-mail response only)
- Guus de Hollander (Netherlands Environmental Assessment Agency)
- Guy Hendrickx (Avia-Gis, Belgium)
- Paul Heyman (Queen Astrid Military Hospital, Belgium)
- Maud Huynen (International Centre for Integrated Assessment & Sustainable Development, Maastricht University)
- Fokke de Jong (Climate changes Spatial Planning, Alterra)
- Loïc Josseran (Institut de Veille Sanitaire, France)
- W.F. Passchier (Department of Health Risk Analysis & Toxicology, Maastricht University)
- J. Schols (Department of General Practice, Maastricht University)
- Aad Sedee (Alterra)
- Tom van Teunenbroek (Ministry of Housing, Spatial Planning and the Environment)
- Arnold van Vliet (Environmental Systems Analysis Group, Wageningen University)
- Arjan Wardekker (Copernicus Institute for Sustainable Development and Innovation, Utrecht University)
- Letty de Weger (Leiden University Medical Center)

Table 6. Participant background.

	No. participants:
a. Nationality and experience	
Dutch, specific experience/expertise in the Netherlands	14
Dutch, no specific experience/expertise in the Netherlands	2
Non-Dutch, specific experience/expertise in the Netherlands	0
Non-Dutch, no specific experience/expertise in the Netherlands	5
b. Professional background	
Scientist	20
Policymaker	3
Policy advisor	5
Health practitioner (medical professional, GGD/public health services, etc.)	2
Other:	4
- dissemination of climate adaptation	
- Started company based on scientific knowledge (spatial modelling vector borne diseases) to bridge gap between research and decision making.	
- MD	
- communication officer	
c. Expertise	
Generalist climate change & health	13
Adaptation	8
Health en adaptation	6
Temperature	4
Allergies	5
Pests	2
Vector-borne diseases	5
Food- and water-borne diseases	1
Air quality-related health effects	3
Flooding- and storm-related health effects	2
UV-related health effects	3
Other:	4
- public health	
- expert on health surveillance in the context of climate change	
- communicating climate change	
- PhD student investigating on quality of information in quantitative microbial risk assessment, making an inventory of the effects of climate change on animal health	

Appendix B. Survey protocol

[page 1]

Expert-survey climate change, uncertainties and human health

(Word-document version)

When completed, please send this survey to: J.A.Wardekker@uu.nl

Web address of online version:
http://www.copernicus.uu.nl/phpESP/public/survey.php?name=ClimateUncertaintyHealth

This survey aims to gain insight into the uncertainties that play a role in the topic of climate change & health in The Netherlands, into the possible relevance of these uncertainties for Dutch climate change adaptation policy, and into uncertainty-robust adaptation strategies. The survey is intended for scientists and professionals with relevant knowledge on climate change & health and climate change adaptation (in general, or health specifically). We intend to publish the results in a scientific report (in Dutch) and an article for an international peer-reviewed journal (in English).

Some questions are fairly expertise-specific. Please answer only those questions you feel capable of answering. Dutch respondents may answer in Dutch, if they feel uncomfortable answering in English.

The survey will take about 0.5-1 hour to complete, depending on how many questions you answer.

After a few background questions (section I), the survey will focus on:

- Possible **level of precision** for health risk estimates (section II). The best-fitting adaptation strategy depends on the level of uncertainty. This section examines this level of uncertainty for various categories of effects.
- Most **relevant uncertainties** and **uncertainty-robust adaptation strategies** (section III). This section will ask you to zoom in on the top-5 most relevant health risks for adaptation in the Netherlands, to further specify the uncertainties for these, and to describe adaptation strategies that are either robust or vulnerable to the uncertainties.

This study is part of a series of ‘case-studies on uncertainty and climate change adaptation’, carried out by Utrecht University (Copernicus Institute) and the Netherlands Environmental Assessment Agency. It is a follow-up of a more theoretical ‘scoping-study’ by Dessai and Van der Sluijs (2007). View the briefing note for more information. Contact: Arjan Wardekker (J.A.Wardekker@uu.nl) or dr. Jeroen van der Sluijs (J.P.vanderSluijs@uu.nl).

[page 2]

I. Introduction

1. What is your name? (for identification and acknowledgement; results will be anonymised)

2. In case you've received the link to this survey via a colleague rather than an e-mail from the research team, please indicate your e-mail address.

3. What would you consider to be your expertise regarding climate change and health? [mark all that apply with 'x']

	Generalist or expert on climate (change) adaptation
	Expert on health and climate (change) adaptation
	Generalist knowledge on climate (change) and health, or one or more topics in this field.
	Expert on temperature-related health effects
	Expert on allergies
	Expert on pests (wasps, oak processionary caterpillar)
	Expert on vector-borne diseases
	Expert on food- and water-borne diseases
	Expert on air quality-related health effects
	Expert on health effects due to flooding and storm
	Expert on UV-related health effects
	Other:

4. What is your professional background? [mark all that apply with 'x']

	Scientist
	Policymaker
	Policy advisor
	Health practitioner (medical professional, GGD/public health services, etc.)
	Other:

5. This study will focus on the Netherlands. As the number of Dutch experts on the topic of 'climate change & health' is limited, we've also invited experts from other countries. Please indicate your background. [mark one that applies with 'x']

	Dutch, and have specific expertise or experience on this topic in the Netherlands
	Dutch, no specific expertise or experience on this topic in the Netherlands
	Non-Dutch, but have specific expertise or experience on this topic in the Netherlands
	Non-Dutch, no specific expertise or experience on this topic in the Netherlands

II. Level of Precision of health risk estimates

In the following sections (per category of effects), you will be asked to indicate the level of precision with which you could estimate the magnitude of each health risk for a number of specific health issues (also take into account interactions between issues), at the present state of knowledge. Assume you would be given some time to review the relevant literature, before you would make the effect estimate.

The level of precision will be rated on a scale based on Risbey & Kandlikar (Climatic Change, 2007). A brief description will be provided on each of the following pages. A full description can be found at: http://www.chem.uu.nl/nws/www/research/risk/LevelOfPrecisionScale.pdf

This section is divided into nine specific subtopics:
a. temperature
b. allergies
c. pests
d. vector-borne diseases
e. food/water-borne diseases
f. air quality-related
g. flooding/storm
h. UV-related
i. (other)

[page 4-5]

IIa. Temperature-related health effects

In this section, you will be asked to indicate the level of precision for health risk estimates regarding climate change & temperature.

Rating:	Label:	Description:
1	Effective ignorance	Knowledge of the factors that govern this effect is so weak that we are effectively ignorant.
2	Ambiguous sign or trend	Some effect is expected, but its sign or trend is not clear. There are plausible arguments either direction (effect could be positive, could be negative; could increase or decrease).
3	Expected sign or trend	It is clear what the sign and trend of the effect will be. However, there is no plausible or reliable information on how strong it will be.
4	Order of magnitude	It is possible to give a rough indication of the magnitude of the effect, a qualitative scoring (e.g. 1-10 scale), or a rough comparison with other effects.
5	Bounds	It is possible to estimate the bounds for the distribution of the effect, e.g. its 5/95 percentiles (effect is only 5% likely to be more than … and only 5% likely to be less than …). However, the shape of the distribution, or best-guess estimates, cannot be provided.
6	Full probability density function	It is possible to provide a full probability density function; the bounds as well as the shape of the distribution.
N/A	Don't know / no answer	

6. Regarding the following specific health issues, with what level of precision would you be able to estimate the magnitude of the health risk for the Netherlands (due to climate change)? Assume you would be given some time to review the relevant literature, before you would make the effect estimate. Use the scale above. [per health issue, mark your rating with 'x']

	1	2	3	4	5	6	N/A
Heat-related mortality							
Heat-related cardiovascular problems (Dutch: hart- en vaatziekten)							
Heat-related respiratory problems							
Heat-related stress and sleep disturbance							
Cold-related mortality (decrease)							
Cold-related diseases (e.g. influenza) (decrease)							
Drought-related exposure to contaminants (less dilution of pollutants during extreme droughts)							
Shortage of drinking water							
Dehydration							

Please provide a brief argumentation for your rating above (if any), and if possible, provide some literature references in support.

7. Argumentation and references for 'heat-related mortality':

8. Argumentation and references for 'heat-related cardiovascular problems':

[REPEAT Q7 FOR ALL OTHER HEALTH EFFECTS UNDER 'TEMPERATURE']

[page 6-13]

[REPEAT ABOVE FOR ALL OTHER HEALTH THEMES:]

Allergies:

- Asthma
- Allergic eczema
- Hay fever: duration of pollen season
- Hay fever: (changes in) pollen types, abundance and allergenicity (e.g. invasive species such as ambrosia, CO2 fertilization, plant stress)

Pests:

- Wasps
- Oak processionary caterpillar (Dutch: eikenprocessierups)

Vector-borne diseases:

- Native vector-borne diseases (e.g. Lyme's disease)
- Incidents of presently non-native diseases (e.g. malaria, West Nile virus, tick-borne encephalitis)
- Possible epidemics of presently non-native diseases (e.g. dengue)

Food- and waterborne diseases:

- Food poisoning (e.g. Salmonella, shellfish poisoning)
- Legionnaires Disease (Dutch: veteranenziekte)
- Contamination of swimming/recreation water (e.g. cyanobacteria (Dutch: blauwalg), Weil's disease, Naegleria fowleri)

Air quality-related effects:

- Respiratory problems due to ground-level ozone
- Respiratory problems due to particulate matter (Dutch: fijn stof)
- Air quality-related cardiovascular problems (Dutch: hart- en vaatziekten)

Flooding and storm:

- Flood-related mortality (e.g. drowning, injury)
- Flood-related infectious diseases (e.g. due to reduced water quality)
- Flood-related exposure to dangerous substances and contaminants
- Flood-related respiratory problems (e.g. due to exposure to fungal spores (Dutch: schimmelsporen) in moistly homes)
- Flood-related mental health problems (e.g. psychological trauma)
- Storm-related mortality and injury

UV-related:

- Cataract (Dutch: oogstaar)
- Skin cancer
- Weakening of the immune system

[page 14]

IIg. Other

47. Are there any other important health issues for the Netherlands (due to climate change) that were not included in the questions above? If so, please indicate these effects plus their level of precision for health risk estimates.

III. Key uncertainties

In the following questions, you will be asked to zoom in on the top five most relevant health effects (of climate change) for climate change adaptation in the Netherlands in view of public health and to examine the uncertainties more closely.

In estimating what health effects are most 'relevant' for Dutch climate change adaptation, take into account the possible magnitude of the health impact, economic impact, public and political perception, and the availability of options for adaptation and control.

Shortlist of health issues:

1. Temperature: Heat-related mortality
2. Temperature: Heat-related cardiovascular problems
3. Temperature: Heat-related respiratory problems
4. Temperature: Heat-related stress and sleep disturbance
5. Temperature: Cold-related mortality
6. Temperature: Cold-related diseases
7. Temperature: Drought-related exposure to contaminants
8. Temperature: Shortages of drinking water
9. Temperature: Dehydration
10. Allergies: Asthma
11. Allergies: Allergic eczema
12. Allergies: Hay fever: duration of pollen season
13. Allergies: Hay fever: pollen types, abundance and allergenicity
14. Pests: Wasps
15. Pests: Oak processionary caterpillar
16. Vector-borne: Native vector-borne diseases
17. Vector-borne: Incidents of non-native vector-borne diseases
18. Vector-borne: Epidemics of non-native vector-borne diseases
19. Food/water-borne: Food poisoning
20. Food/water-borne: Legionnaires Disease
21. Food/water-borne: Contamination of swimming/recreation water
22. Air quality: Respiratory problems due to ground-level ozone
23. Air quality: Respiratory problems due to particulate matter
24. Air quality: Air quality-related cardiovascular problems
25. Flood/storm: Flood-related mortality
26. Flood/storm: Flood-related infectious diseases
27. Flood/storm: Flood-related exposure to dangerous substances and contaminants
28. Flood/storm: Flood-related respiratory problems
29. Flood/storm: Flood-related mental health problems
30. Flood/storm: Storm-related mortality and injury
31. UV: Cataract
32. UV: Skin cancer
33. UV: Weakening of the immune system
34. OTHER (indicate in question)

48. **Most relevant effect**: [indicate the number from the list above]

49. What makes this effect relevant for the Netherlands (brief description or keywords suffices)?

50. Please describe the key uncertainties that play a role in estimating the magnitude of this health risk. If possible, indicate relevant literature references.

51. Could you describe which adaptation options/strategies would be particularly well-capable of dealing with these uncertainties and which would be very vulnerable to them (and why?)?

[REPEAT ABOVE FOR 2ND, 3RD, 4TH, AND 5TH MOST RELEVANT HEALTH EFFECTS]

If there is anything else you would like to add, suggest or clarify regarding climate change, health, adaptation and uncertainties, you can do so in the field below.

68. Any other things you would like to add, suggest or clarify?

[END OF SURVEY]

Appendix C. Survey results

C.1. Tables of the 'Level of Precision' scores

Table 7. Scores per health effect.

	Health effect:	Score						N per question:
		1	2	3	4	5	6	
1	Temperature: Heat-related mortality				9	3	2	14
2	Temperature: Heat-related cardiovascular problems		0.5	9.5	3	1	1	15
3	Temperature: Heat-related respiratory problems			11	3	2		16
4	Temperature: Heat-related stress and sleep disturbance		1	8	5			14
5	Temperature: Cold-related mortality		3	2	7	2	1	15
6	Temperature: Cold-related diseases	1	2	7	3	2		15
7	Temperature: Drought-related exposure to contaminants		5	6	2			13
8	Temperature: Shortages of drinking water		3	3	5		1	12
9	Temperature: Dehydration		5	5	3	1		14
10	Allergies: Asthma	1	4	7	1			13
11	Allergies: Allergic eczema	1	5	3				9
12	Allergies: Hay fever: duration of pollen season			10	2	3		15
13	Allergies: Hay fever: pollen types, abundance and allergenicity		1	10	2	2		15
14	Pests: Wasps	1	3	2	1	1		8
15	Pests: Oak processionary caterpillar			1	8	2		11
16	Vector-borne: Native vector-borne diseases		7	4	5	1		17
17	Vector-borne: Incidents of non-native vector-borne diseases	1.25	5.25	5.25	4.25			16
18	Vector-borne: Epidemics of non-native vector-borne diseases	1.25	6.75	4.75	2.25			15
19	Food/water-borne: Food poisoning	1	1	6	5			13
20	Food/water-borne: Legionnaires Disease		2	7	2	1		12
21	Food/water-borne: Contamination of swimming/recreation water			4	7	1		12
22	Air quality: Respiratory problems due to ground-level ozone		1.5	4.5	4	2		12
23	Air quality: Respiratory problems due to particulate matter		1.5	3.5	3	2		10
24	Air quality: Air quality-related cardiovascular problems		2	3	3	2		10
25	Flood/storm: Flood-related mortality		4	2	2.5	3.5		12
26	Flood/storm: Flood-related infectious diseases		5	5	1			11
27	Flood/storm: Flood-related exposure to dangerous substances and contaminants	1	5	3	2			11
28	Flood/storm: Flood-related respiratory problems	1	3	5	1	1		11
29	Flood/storm: Flood-related mental health problems		2	7	1			10
30	Flood/storm: Storm-related mortality and injury		3	3	4	1		11
31	UV: Cataract	1	3	1	1	3		9
32	UV: Skin cancer	1	3	2	2	4		12
33	UV: Weakening of the immune system	2	3	1	2	1		9

Table 8. Total scores expressed in percentages.

Health effect:	Score: 1	2	3	4	5	6
1				64	21	14
2		3	63	20	7	7
3			69	19	13	
4		7	57	36		
5		20	13	47	13	7
6	7	13	47	20	13	
7		38	46	15		
8		25	25	42		8
9		36	36	21	7	
10	8	31	54	8		
11	11	56	33			
12			67	13	20	
13		7	67	13	13	
14	13	38	25	13	13	
15			9	73	18	
16		41	24	29	6	
17	8	33	33	27		
18	8	45	32	15		
19	8	8	46	38		
20		17	58	17	8	
21			33	58	8	
22		13	38	33	17	
23		15	35	30	20	
24		20	30	30	20	
25		33	17	21	29	
26		45	45	9		
27	9	45	27	18		
28	9	27	45	9	9	
29		20	70	10		
30		27	27	36	9	
31	11	33	11	11	33	
32	8	25	17	17	33	
33	22	33	11	22	11	

Table 9. Scores for key experts.

Health effect:	Score: 1	2	3	4	5	6
1				2	1	
2			2		1	
3			2		1	
4		1	2			
5		1		1	1	
6	1		1		1	
7		1	1			
8		1		1		
9		1	1		1	
10			4			
11		1	1			
12			4	1		
13			5			
14		1	1			
15				2		
16		3	1	1		
17	0.25	2.25	2.25	0.25		
18	0.25	2.25	1.25	0.25		
19				1		
20				1		
21				1		
22				2	1	
23				2	1	
24				2	1	
25				0.5	1.5	
26		1	1			
27		2				
28			1	1		
29			2			
30			2			
31	1				2	
32	1				2	
33	1			1	1	

C.2. Arguments for 'Level of Precision' scores

This section lists the arguments for 'level of precision' scores, per score value. E.g. the arguments given for a score of 3 ('expected sign/trend'), followed by the arguments given for a score of 4 ('order of magnitude') and so on.

Temperature in general	
No rating	Uit de statistieken blijkt dat klimatologische omstandigheden een aanzienlijk effect hebben op de oversterfte. De epidemiologen houden zich bezig met het goed registeren daarvan en ook het CBS doet mee. Wat echter ontbreekt zijn goede studies waarin het waarom van de oversterfte in kaart wordt gebracht. Hier is naar mijn mening een gebrek aan inzicht, alleen Keatinge in de UK heeft hieraan gewerkt. Dit gebrek aan inzicht leidt er ook toe dat we niet weten of en hoe we interventies moeten maken. Noodzakelijk is het dat epidemiologen, thermofysiologen, gedragswetenschappers en artsen samenwerken om dit inzicht te verkrijgen omdat pas dan gerichte interventies gedaan kunnen worden. De maatschappelijke impact van klimaatgerelateerde oversterfte is groot.
Temperature: Heat-related mortality	
4	- Limited empirical information for heat-mortality relationship for the specific Dutch situation (huynen et al 2001 EHP) - difficulties in in estimating/modeling the future intensity, duration and frequency of heat waves, although increasing trend is expected by the IPCC (2007) - uncertainties in adaptive capacity (see e.g. the EUROhat project coordinated by the WHO)
	Many data already, however, projections still difficult to make because of possible confounders, change of CR function, demographic changes and impact of adaptation measures unknown
	Experience with and data from heat strokes in 2003 a.o.
	Effects known; context not
	Much research and data is available on the relation between heat and mortality. There are however substantial differences in response functions of different locations and the reasons behind this are unclear. Also the effects of autonomous adaptation (physical and behaviour) are not known (also dependant on climate scenario), and there are many interactions with other factors (e.g. socio-economic, air quality, harvesting effect, demographics etc.).
	specific in urban areas
	see information of conference Climate change and health, Oploopdebat 'Klimaatverandering en Gezondheid' Donderdag, 18 september 2008, door Kennis voor Klimaat Book: Mondiale milieuveranderingen en volksgezondheid o.a. Maud Huynen and Heatwaveplan 2008 on site www.rivm.nl
5	from what is known from literature
	Confalonieri, U., Menne, B., Akhtar, R., Ebi, K.L., Hauengue, M., Kovats, R.S., Revich, B., and Woodward, A., Human health. Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, in Report of the Intergovernmental Panel on Climate Change (M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds.). 2007, Cambridge University Press: Cambridge. Huynen, M.M.T.E., de Hollander, A.E.M., Martens, P., and Mackenbach, J.P., Mondiale milieuveranderingen en volksgezondheid: stand van de kennis. 2008, RIVM: Bilthoven. Please contact Bianca Cox (Scientific Institute of Public health, Brussels) concerning heat-related mortality in Belgium.
6	links between mortality and heat are now well known. If few information is available it is not so difficult to tune a model for mortality surveillance or expected mortality. We did this job in France.
Temperature: Heat-related cardiovascular problems	

2-3	Climate change is not just heat-related. Many people would feel a warmer climate as more comfortable: rating 2. But a hot summer in a metropolitan area would give a rating 3.
3	- limited empirical information >studies on cardiovascular mortality limited (huynen et al 2001 EHP), studies on cardiovascular disease - absent for the Netherlands - difficulties in estimating/modeling the future intensity, duration and frequency of heat waves, although increasing trend is expected by the IPCC (2007) - uncertainties in adaptive capacity
	Few indications only, data base too limited to make assessments, impact of adaptation measures unknown
	specific for elderly people problems expected
	Some data available, but not enough to make reliable estimates of the effects of the magnitude of the effect of climate change.
	Same as above (effects known; context not), but necessary more specific drivers not known
	especially in the elderly well documented
4	see information of conference Climate change and health, Oploopdebat 'Klimaatverandering en Gezondheid' Donderdag, 18 september 2008, door Kennis voor Klimaat Book: Mondiale milieuveranderingen en volksgezondheid o.a. Maud Huynen and Heatwaveplan 2008 on site www.rivm.nl
	Experience with and data from heat strokes in 2003 a.o.
5	literature and epidemiological data
Temperature: Heat-related respiratory problems	
3	- limited empirical information >studies on respiratory mortality limited, studies on respiratory disease absent for the Netherlands - difficulties in estimating/modeling the future intensity, duration and frequency of heat waves, although increasing trend is expected by the IPCC (2007) - uncertainties in adaptive capacity
	Few indications only, data base too limited to make assessments, impact of adaptation measures unknown
	Same as above (effects known; context not), but necessary more specific drivers not known
	Some data available, but not enough to make reliable estimates of the effects of the magnitude of the effect of climate change.
	ozone problems summer smog
	specific for elderly people problems expected
	Mijn expertise is op het gebied van hooikoorts. De hooikoorts klachten zijn gerelateerd aan pollen in de lucht en deze kunnen beïnvloed worden door klimaatseffecten. (i) De pollenhoeveelheid kan veranderen (ii)en de bloeiseizoenen kunnen verschuiven (iii) er kunnen nieuwe allergene plantensoorten verschijnen (iv) de allergeniciteit van de pollen kan veranderen
	Beware for mixing cause-effect relationships with air quality. Both occur simultaneously within densely populated urban areas.
4	see information of conference Climate change and health, Oploopdebat 'Klimaatverandering en Gezondheid' Donderdag, 18 september 2008, door Kennis voor Klimaat Book: Mondiale milieuveranderingen en volksgezondheid o.a. Maud Huynen and Heatwaveplan 2008 on site www.rivm.nl
	Experience with and data from heat strokes in 2003 a.o.
5	literature and epidemiological data
Temperature: Heat-related stress and sleep disturbance	
2	? experience
3	Few indications only, data base too limited to make assessments, impact of adaptation measures unknown
	depending on adaptive capacity I'm not familiar with literature on heat and sleep disturbance, but I have been informed by a thermofysiologist (Hein Daanen, TNO) that studies are available

	Same as above (effects known; context not), but necessary more specific drivers not known
	Some data available, but not enough to make reliable estimates of the effects of the magnitude of the effect of climate change.
4	well documented from hospital references
	for young and old people expected
	see information of conference Climate change and health, Oploopdebat 'Klimaatverandering en Gezondheid' Donderdag, 18 september 2008, door Kennis voor Klimaat Book: Mondiale milieuveranderingen en volksgezondheid o.a. Maud Huynen and Heatwaveplan 2008 on site www.rivm.nl
	Experience with and data from heat strokes in 2003 a.o. International literature.
Temperature: Cold-related mortality	
2	-limited empirical information for cold-mortality relationship for the specific Dutch situation (huynen et al 2001 EHP) - difficulties in estimating/modeling difficulties in estimating/modeling the future intensity, duration and frequency of cold spells and cold temperature. - Decreasing trend in cold mortality is most likely according to the IPCC (2007), but his might depend on adaptation assumption -> In case the wind patterns over Europe will change (KNMI'06 sce4narios W+ and G+, the temperature distribution will become wider -> the difference between winter temperatures and annual average temperature will become larger. In case we assume adaptation by shifting our optimal temperature (e.g. with lowest mortality) parallel to the increase in average annual temperature (assumed in several international studies), winter mortality could actually increase. This has only be demonstrated in one study (Huynen 2008). - Hence, uncertainties in adaptive capacity result in uncertainties regarding this effect....
	the Dutch society can deal with cold stress periods. Less periods are expected
	government statistics
3	Literature data from abroad
4	Many data already, however, projections still difficult to make because of possible confounders, change of CR function, demographic changes and impact of adaptation measures unknown
	see information of conference Climate change and health, Oploopdebat 'Klimaatverandering en Gezondheid' Donderdag, 18 september 2008, door Kennis voor Klimaat Book: Mondiale milieuveranderingen en volksgezondheid o.a. Maud Huynen and Heatwaveplan 2008 on site www.rivm.nl
	Effects known; context not.
	Much research and data is available on the relation between heat and mortality. There are however substantial differences in response functions of different locations and the reasons behind this are unclear. Also the effects of autonomous adaptation (physical and behaviour) are not known (also dependant on climate scenario), and there are many interactions with other factors (e.g. socio-economic, air quality, harvesting effect, demographics etc.).
	Confalonieri, U., Menne, B., Akhtar, R., Ebi, K.L., Hauengue, M., Kovats, R.S., Revich, B., and Woodward, A., Human health. Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, in Report of the Intergovernmental Panel on Climate Change (M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds.). 2007, Cambridge University Press: Cambridge. Huynen, M.M.T.E., de Hollander, A.E.M., Martens, P., and Mackenbach, J.P., Mondiale milieuveranderingen en volksgezondheid: stand van de kennis. 2008, RIVM: Bilthoven. Brits, E., Boone, I. et al. (2009). Climate Change and Health. Monitoring the effects of climate change on human and animal health
5	epidemiology
Temperature: Cold-related diseases	
1	it is still unclear why influenza is a seasonal disease, so lack of knowledge about current temperature-influenza relationship.

	CVD and Respiratory disease might be affected, but see under 11 for uncertainties...
2	The Dutch society can deal with cold stress periods. Less periods are expected
3	Same as above (effects known; context not), but necessary more specific drivers not known
	Some data available, but not enough to make reliable estimates of the effects of the magnitude of the effect of climate change.
	Literature data from abroad
4	Few indications only, data base too limited to make assessments, impact of adaptation measures unknown
	see information of conference Climate change and health, Oploopdebat 'Klimaatverandering en Gezondheid' Donderdag, 18 september 2008, door Kennis voor Klimaat Book: Mondiale milieuveranderingen en volksgezondheid o.a. Maud Huynen and Heatwaveplan 2008 on site www.rivm.nl
	ambiguous body of literature
5	epidemiology and literature
Temperature: Drought-related exposure to contaminants	
2	Unknown how this will work out with a well-prepare societal care system
	the key notion here is "drought related" lots of that on dust bowl situations however the likelihood of the occurrence is never estimated
3	Few indications only, data base too limited to make assessments, impact of adaptation measures unknown
	One might expect this health risk to increase due to increasing droughts and higher temperatures, the latter of which could also increase the population exposed due to more water-based recreation. However, to my knowledge little data exists to assess this risk.
	extrapolation
Temperature: Shortages of drinking water	
2	Few indications only, data base too limited to make assessments, impact of adaptation measures unknown
	Unknown how this will work out with a well-prepare societal care system
3	we have seen some problems in 2003 in NL; will occur frequently
4	reports
	modelling
	While calculations may be possible on water shortages, the translation to actual health impacts would be very difficult. However, a maximum order of magnitude could be suggested, because short term abatement options are available (e.g. importing water from elsewhere) for a wealthy country such as the Netherlands. One can expect that the government would intervene if water shortages would become problematic.
	see information of conference Climate change and health, Oploopdebat 'Klimaatverandering en Gezondheid' Donderdag, 18 september 2008, door Kennis voor Klimaat Book: Mondiale milieuveranderingen en volksgezondheid o.a. Maud Huynen and Heatwaveplan 2008 on site www.rivm.nl
6	no problem whatsoever bigger problem is the lack of cooling-water for utilities and its effect on health
Temperature: Dehydration	
2	Few indications only, data base too limited to make assessments, impact of adaptation measures unknown
	There could be an effect due to higher temperatures and more heat waves, but it could also not occur. It also depends on people's behaviour (will they drink more, will people make sure that e.g. elderly people will receive sufficient water, etc.). To my knowledge, there is too little information to assess this.
	Unknown how this will work out with a well-prepare societal care system

3	extrapolation
4	see information of conference Climate change and health, Oploopdebat 'Klimaatverandering en Gezondheid' Donderdag, 18 september 2008, door Kennis voor Klimaat Book: Mondiale milieuveranderingen en volksgezondheid o.a. Maud Huynen and Heatwaveplan 2008 on site www.rivm.nl
	well documented among nursery homes especially elderly food and drink patterns
5	experience, literature

Allergies: Asthma	
1	This category is too broad. The interplay of determinants is unknown
2	See Huynen and Menne 2003.
	More than one cause, not all in the same direction. Unclear which one will dominate.
	The problem with these cause-effect relationship is the contribution from non-climate change indicators, such as land use, traffic use etc. Another uncertainty is the time integration. If climate warms, winter effects could be different from summer effects. May be even opposite.
3	It is known that a large percentage of the people that have asthma also have hay fever. Therefore it is highly likely that changes in the timing, duration, allergenicity, type of, and intensity of pollen will change the health risks related to asthma. Especially when the weather conditions will become more favourable for the flight of pollen. It is unclear what the magnitude of the health impacts will be under the different climate change scenarios.
	Lack of data
	While much research has been done, the development of asthma is a highly multi-factoral issue, and much is not or only partly known. While an increased risk is expected via climatic effects on allergens (pollen, dust mite, moulds, etc.), quantification is not yet possible.
	not clear yet if there is a strong correlation
4	see information of conference Climate change and health, Oploopdebat 'Klimaatverandering en Gezondheid' Donderdag, 18 september 2008, door Kennis voor Klimaat Book: Mondiale milieuveranderingen en volksgezondheid o.a. Maud Huynen and Heatwaveplan 2008 on site www.rivm.nl
Allergies: Allergic eczema	
1	This category is too broad. The interplay of determinants is unknown
2	More than one cause, not all in the same direction. Unclear which one will dominate.
	See Huynen and Menne 2003.
	The problem with these cause-effect relationship is the contribution from non-climate change indicators, such as land use, traffic use etc. Another uncertainty is the time integration. If climate warms, winter effects could be different from summer effects. May be even opposite.
3	Lack of data
	not clear yet if there is a strong correlation
Allergies: Hay fever: duration of pollen season	
3	It is very likely that the duration of the pollen season will increase in The Netherlands due to climate change. It is however unclear what the magnitude of the health impacts will be as it will largely depend on the response of patients and the medical sector to the changes in the duration of the pollen season. As up to 15% of the people suffer from hay fever, the health or socio-economic impacts can be substantial. However, they have not been quantified.

	Phenological studies have shown an increase in the length of the pollen season for some species during the past decades, and this can be linked to increasing (spring) temperatures. Other species do not show a trend or only shift to an earlier start, and it is not known whether the pollen season will expand these species in the future. Overall, an increase in health risk is expected due to climate change. However, the magnitude of the health impact is unclear. Particularly, the effect of the longer season on the actual duration and intensity of exposure to pollen is unknown. Also, it has been suggested that increased exposure could lead to higher incidence of hay fever, but much remains uncertain concerning this issue. And further, as noted in 17, allergy is a multi-factoral issue.
	de duur van het seizoen kan veranderen door klimaatsverandering. Dit kan per pollensoort verschillen. Voor de berk blijkt in Nederland het seizoen wel naar voren te schuiven maar het wordt niet signifcant verlengd (het einde schuift ook naar voren). Voor graspollen zien we voor de 2 pollentelstations in Nederland verschillende trends; enerzijds geen verlenging van het seizoen en in het andere telstation wel een verlenging.
	See Huynen and Menne 2003. See PhD thesis Arnold van Vliet (2008), demonstrating that the pollen season for some allergens has increased. link with temperature (change) is expected
	Some indications, but interplay of determinants is unknown.
4	There is only limited data, although rough estimations could be made be. Impact of adaptation measures, e.g. low allergenic green zones, or use of medicines, is however unknown.
	see information of conference Climate change and health, Oploopdebat 'Klimaatverandering en Gezondheid' Donderdag, 18 september 2008, door Kennis voor Klimaat Book: Mondiale milieuveranderingen en volksgezondheid o.a. Maud Huynen and Heatwaveplan 2008 on site www.rivm.nl
5	Lots of recent literature and data
	signs of increasing this problem
Allergies: Hay fever: pollen types, abundance and allergenicity	
3	Door de klimaatsverandering kunnen nieuwe soorten zich mogelijk vestigen in Nederland. Ambrosia is daarvan een voorbeeld. Vooralsnog neemt het aantal ambrosiapollen in de lucht niet toe. Wel worden er meer planten gezien waarschijnlijk omdat het zaad in vogelvoer voorkomt en dus elke winter wordt 'uitgezaaid' in de achtertuinen. Wat betreft de allergeniciteit zijn er in de literatuur aanwijzingen dat bij verhoogde CO2 concentraties de allergeniciteit van pollen toeneemt.
	Lack of data, specifically on types of pollen and allergenicity
	Due to climate change, the Dutch climate will become more suitable for species currently found primarily in warmer regions. Some particularly allergenic species such as Ambrosia (ragweed) and olive trees are on the increase in the Netherlands. Experiments have also show increases in abundance and allergenicity of pollen due to several climate-related factors. What this will imply for the magnitude of health impacts (via e.g. severity of symptoms, hay fever incidence, etc.) is unknown. Increased health risks can be expected, but the magnitude is unclear.
	It is very likely that with a change in climate new species will appear or that their population sizes will increase in The Netherlands that used to grow in southern countries. Examples are Ragweed (Ambrosia), Parietaria (Klein glaskruid) and the olive tree. The last one because more people will plant this species in their gardens. The number of locations where these species are found in The Netherlands is already increasing. Van Vliet et al 2009. Toekomstschets ambrosia komt later dit jaar beschikbaar. Daarin staan veel referenties. Uit deze toekomstschets wordt duidelijk dat het zeer waarschijnlijk dat ambrosia zich hier verder zal gaan uitbreiden. Met de toename in het aantal warme en tropische dagen zal ook het aantal dagen met gunstig weer voor hoge pollenconcentraties toenemen. Er komen ook meer aanwijzingen dat de allergeniciteit van pollen toeneemt in situaties met hoge concentratie luchtverontreiniging. Warmer weer leidt tot hogere concentraties luchtverontreiniging en daarmee mogelijk ook tot meer gezondheidsklachten. De mate waarin dit zal optreden is nog onduidelijk.
	See Huynen and menne 2003 Ambrosia is spreading/blooming in the Netherlands see de website from the natuurkalender

	Some indications, but interplay of determinants is unknown.
4	see information of conference Climate change and health, Oploopdebat 'Klimaatverandering en Gezondheid' Donderdag, 18 september 2008, door Kennis voor Klimaat Book: Mondiale milieuveranderingen en volksgezondheid o.a. Maud Huynen and Heatwaveplan 2008 on site www.rivm.nl
5	Lots of recent literature and data
	signs of increasing this problem

Pests: Wasps	
1	New to me
2	The last couple of years we see that the queens of wasps wake up earlier in spring after hibernation due to the exceptionally high temperatures in winter and early spring. Furthermore, in some years the weather conditions due to the vulnerable phase of the queen wasps (April) were very good. This resulted in larger amounts of wasps nests and more wasps (see www.natuurkalender.nl). Every year a few people die after a wasp sting due to allergic reactions. Due to the more frequent warm winters the survival of queen wasps during winter time might also be reduced resulting in lower amounts of wasps. This is still completely unclear.
	Warmer spring temperatures could result in wasp queens waking earlier and more favourable conditions for further development of wasp nests could result in more wasps during a longer period of time. This would increase health problems. However, warm episodes in winter might disturb wasp queens' hibernation, resulting in die-off in subsequent colder/freezing episodes. The total effect remains to be seen.
	is there an specific increase?
3	Lack of data
4	the occurrence of hornets will become more likely risk documentation very extensive esp. Japan
Pests: Oak processionary caterpillar	
3	Observed increase in past year might be attributable to climatic factors. See website Natuurkalender.
4	The Oak processionary caterpillar entered the south of The Netherlands in the early 1990's and is gradually but rapidly expanding its distribution in northwards direction. This year it reached the south of the province of Drenthe. Based on the climate change scenarios of the KNMI we expect that he will be present in the whole of the country by 2020 but this might already be earlier. The population size will also increase significantly. As we are not able to remove the caterpillars effectively and the urticating hairs of the caterpillar will cause problems for 8 years, it is expected that the coming years large amounts of people will be confronted with health complaints. The health impacts of the OPC are described in a report by the GGD but it is unknown what the current and potential future magnitude of the problem is.
	Several indications, rough disease estimations exist
	statistics GGD
	there is certainly an increase, which has been investigated by Natuurkalender
	see information of conference Climate change and health, Oploopdebat 'Klimaatverandering en Gezondheid', donderdag, 18 september 2008, door Kennis voor Klimaat Book: Mondiale milieuveranderingen en volksgezondheid o.a. Maud Huynen and Heatwaveplan 2008 on site www.rivm.nl
	We can expect a further spread of the caterpillar from the south, eventually covering the whole of the Netherlands, as conditions will become more favourable. Population size will likely increase as well. Based on this scenario, and the effects currently observed in regions that are affected by the caterpillar, rough estimates could be made for health effects.
	I have no personal experience with this best, but we do have experience with insect vectors of disease. If data about distribution and or abundance shifts from elsewhere, but in similar eco-climatic settings are available rough estimates of shifts here could be made.

5	Lot of information from recent years
Pests: OTHER: Mosquitoes	
3	Muggen brengen nu nog geen ziekten over maar zijn al wel heel vervelend. Verwacht wordt dat het actieve seizoen langer zal worden en dat de aantallen muggen zullen toenemen in ons land. Zie http://www.natuurbericht.nl/default.asp?cat=&id=1548 en het daar genoemde rapport van Verdonschot. De overlast zal verder toenemen indien ook muggensoorten als de Tijgermug zich in ons land gaan vestigen. Deze mug steekt veel venijniger dan de muggen die we al in ons land hebben en ze steken ook nog eens overdag. 'Onze' muggen doen dat niet of nauwelijks. De kwaliteit van leven voor grote aantallen mensen zal substantieel afnemen (ook nachtrust) zeker als er ook de dreiging van ziekten bijkomt.

Vector-borne: Native vector-borne diseases	
No rat-ing	Even though the incidence of this disease may affected (possibly upwards), I do not have the expertise to answer the question in a more definite way.
2	Lyme is the only endemic human vector-borne disease of any importance in the Netherlands. Lyme has been discovered in the Netherlands only recently (mid 1980's), while some evidence indicates that the disease has been endemic in Europe for at least a century. The short period of available data makes conclusions on the effect of climate uncertain. see also arguments in next box [Argumentation and references for 'incidents of presently non-native diseases': Changes in temperature and moisture affect cold-blooded animals in nature like ticks and insects. However, vector-borne diseases are the result of extremely complex interactions between vector-warmblooded reservoirs-humans and their environment and it is highly unlikely that climate change has a uni-directed affect on these interactions. The effect, even its sign for a single disease let alone the vector-borne diseases as a whole, will be difficult to predict. Lafferty K.D. Ecology 90:888-900, and addition articles of this Ecology issue. Randolpg and Rogers 2000 Proc. R. Soc. Lond. B (2000) 267, 1741-1744]
	We are strongly convinced, given available evidence, that recent changes in occurrence of native VBD's in general and Lyme in particular are multifactorial and not solely or even not mainly caused by climate shifts. Increased contact due to socio-economic changes is one of these.
	observed strong increase in Lyme might be attributable to climate change, but other factors should be considered as well. - longer season is observed, with tick bites even in winter (website natuurkalender). - The RIVM identified Lyme disease as one of the vector borne diseases that might be affected by climate change in the Netherlands (Staat van infectieziekten 2007, RIVM) - Effect of temperature change on complex disease ecology not well understood. Some literature suggests that the temperature might effect timing of the feeding of larvae and adults -> affecting co-feeding and the transmission of the pathogen)
	recent research at Wageningen regarding the infection of ticks on wildlife
	Although there is an increase in Lyme disease incidence in Belgium since 1998, it is unclear what the exact direct impact of climate change is. Temperature and moisture changes are not enough to explain this increase. According to Lindgren et al. (2006, Lyme borreliosis in Europe: influences of climate and climate change, epidemiology, ecology and adaptation measures) climate change will facilitate spread of Lyme disease into higher altitudes and latitudes in non-endemic areas and contribute to increased incidence in endemic areas, but locally, where conditions will be too hot or try, Lyme disease incidence may decrease / disappear. Climate change will have an influence on the increased distribution of mosquito-borne viral diseases (such as West-Nile Virus), but most likely other factors often due to human intervention will have a larger influence on the increased risk of transmission. Capelli, G., Dekker, A., Gale, P., Lindberg, A., Lipowski, A., Meller, P., Phipps, P., Snary, E., Ulrich, R., and Yin, H., Workpackage 7.4:- Impact of environmental effects on the risk of the occurrence of epizootic diseases in Europe: Identification and prioritisation. Hazard Identification. 2009, EPIZONE.

3	The number of people diagnosed with Lyme disease increased threefold in 10 years time. It is unclear what the cause of the increase is. In the context of the Nature's Calendar project we are monitoring the population size and dynamics of ticks as well as the percentage of ticks that are infected with the borrelia bacteria that causes Lyme. We are analysing the data at the moment. What is already clear is that the activity season is becoming larger during warm winters. For more information on vector borne diseases in Europe see: Semenza and Menne, 2009. Climate change and infectious diseases in Europe. The Lancet 9: 365-375.
	Climate change will improve the conditions for ticks in the Netherlands, and therefore likely result in higher health risks associated with Lyme's disease. However, the relative effect of climate change compared to other trends and conditions (e.g. trends in ground cover, urbanisation, human behaviour such as recreation, etc) is unclear. The reasons for current Lyme trends in the Netherlands are not clear either. Therefore, although an effect is expected, its magnitude cannot yet be determined.
4	Several data, rough estimations could be made, although the precise role of CC versus other factors (more outdoor activity, earlier diagnosis, is still difficult to assess.
	see information of conference Climate change and health, Oploopdebat 'Klimaatverandering en Gezondheid' Donderdag, 18 september 2008, door Kennis voor Klimaat Book: Mondiale milieuveranderingen en volksgezondheid o.a. Maud Huynen and Heatwaveplan 2008 on site www.rivm.nl
	This has been shown by researchers of Maastricht University
	opinions
5	Lots of data available
Vector-borne: Incidents of non-native vector-borne diseases	
No rating	Even though the incidence of this disease may affected (possibly upwards), I do not have the expertise to answer the question in a more definite way.
1	-Climate plays an important role in the spread, distribution and transmission of vector-borne diseases. The RIVM suggests that is unclear that climate change in the Netherlands will affect the risk from these vector borne diseases (Staat van infectieziekten 2007, RIVM)
1, 2, 3, & 4	This is very variable from disease to disease: - Malaria resurgence risk is NOT depending on climate change. Remember Europe (and the Netherlands) was only very recently freed from malaria. All vectors are still there. It is mainly because (a) EU is rich enough to detect imported cases, (b) imported cases often don't have contact with malaria mosquitoes, (c) imported positive mosquitoes remain restricted to airport surroundings, that the disease doesn't establish itself. - WNV. WNV is on this list because what happened in the US. This is not comparable to the situation in EU. WNV is endemic to Europe, is reintroduced each year and doesn't spread as it did in the US. Also in the US the spread of WNV had nothing to do with climate change, but was caused by increased global traffic and the fact that the virus found a receptive native mosquito and bird population in which the disease exploded. Something comparable MAY occur in Europe with Saint Louis Encephalitis imported from the US. - TBE: much of the observed shifts have been caused by socio-economic changes and increased contact. In general we thus disagree with simple graphs showing increased temperature and increased occurrence of any disease. Reality is multifactorial and far more complex than that. This complexity should not be avoided. From a research point of view more studies are needed on the impact of climate shifts on the live cycle of arthropod vectors and of pathogens on subsequent generations of organisms. Here also too rapidly conclusions are drawn such as: temp increase, faster growth, more offspring, etc = more risk. This is not necessarily the case: I remember a conference where a researcher (can't find ref) showed that indeed ticks were ovipositioning at higher altitudes in Czech Land, but hatching and viability larvae was far below average. etc. etc. So please stop drawing fast and easy politically correct conclusions on this topic and look at facts and proper analyses.

2	Changes in temperature and moisture affect cold-blooded animals in nature like ticks and insects. However, vector-borne diseases are the result of extremely complex interactions between vector-warmblooded reservoirs-humans and their environment and it is highly unlikely that climate change has a uni-directed affect on these interactions. The effect, even its sign for a single disease let alone the vector-borne diseases as a whole, will be difficult to predict. Lafferty K.D. Ecology 90:888-900, and addition articles of this Ecology issue. Randolpg and Rogers 2000 Proc. R. Soc. Lond. B (2000) 267, 1741-1744
	Please contact experts listed in Belgian_experts.doc. (Dr. VAN BORTEL Wim, Dr Guy Hendrickx, Dr. DUCHEYNE Els, Prof Fons Van Gompel, Dr MADDER Maxime,...) Tick-borne encephalitis: The complexity of tick-borne disease systems makes a simple monotonic response to climate change unlikely, despite the sensitivity of many intrinsic biological processes to climatic conditions : Randolph, S.E. (2008). Dynamics of tick-borne disease systems: minor role of recent climate change. Revue Scientifique et Technique 27, 367-381. See also presentation Marion Wooldridge Climate change and the pathogen challenge (http://www.mdaoa.ulg.ac.be/Conference/PDF/2009-Marion_Wooldridge.pdf). 14^{th} conference on food microbiology, Liege, June 2009.
3	See Semenza and Menne 2009
	Only a few indications, precise role of CC is still difficult to assess, and nature, extent, and tempo therefore difficult to judge.
	malaria was an endemic disease in the Netherlands (Biesbos) in the late 1800 beginning 1900 occurrence of malaria mosquitoes around airports is increasing spread into other vectors is more likely
	For some diseases conditions for incidental occurrence will improve, for others it seems unlikely that they will spread to the Netherlands. How often such incidents will occur and how serious the consequences will be, depends on a great deal of factors on which knowledge is lacking (and sometimes indeterminable).
4	opinions
	This has been shown by researchers of Maastricht University
	Data available but not complete

Vector-borne: Epidemics of non-native vector-borne diseases

No rat-ing	Even though the incidence of this disease may affected (possibly upwards), I do not have the expertise to answer the question in a more definite way.
1	-Climate plays an important role in the spread, distribution and transmission of vector-borne diseases. The RIVM suggests that is unclear that climate change in the Netherlands will affect the risk from these vector borne diseases (Staat van infectieziekten 2007, RIVM)
1, 2, 3, & 4	Given the above, of course predicting non-native vectors and diseases, surely is far more complex. Chikungunya is a nice example: - Albopictus introduced on Mediterranean due to global trade in spare tires. Strain is adapted to temperate climate and winter diapause. This is not the case with the tropical strains regularly re-introduced in greenhouses in NL. - Spreading along transport routes, not because of climate shifts. If as in US almost all Europe is at risk (see our ECDC report). - Chikungunya introduced by tourists in Italy in established overwintering albo pop. - Disease was controlled and didn't resurge year after. - The good news is: tropical pathogen may not be adapted to our climate to stay. We thus are most likely at risk of temporal introductions during the good season. Nevertheless, the most important studies to conduct are studies about viral development at various outside temperatures in established mosquito strains. Dengue thus is currently unpredictable.

2	the same argument as above: Changes in temperature and moisture affect cold-blooded animals in nature like ticks and insects. However, vector-borne diseases are the result of extremely complex interactions between vector-warmblooded reservoirs-humans and their environment and it is highly unlikely that climate change has a uni-directed affect on these interactions. The effect, even its sign for a single disease let alone the vector-borne diseases as a whole, will be difficult to predict. Lafferty K.D. Ecology 90:888-900, and addition articles of this Ecology issue. Randolpg and Rogers 2000 Proc. R. Soc. Lond. B (2000) 267, 1741-1744 In addition, factors other than climate change (e.g socio-economic, travel, global trade) play likely a more important role in the emergence of vector-borne diseases and possible epidemics.
	Please contact experts listed in Belgian_experts.doc. (Dr. VAN BORTEL Wim, Dr Guy Hendrickx, Dr. DUCHEYNE Els, Prof Fons Van Gompel, Dr MADDER Maxime,...) Tick-borne encephalitis: The complexity of tick-borne disease systems makes a simple monotonic response to climate change unlikely, despite the sensitivity of many intrinsic biological processes to climatic conditions : Randolph, S.E. (2008). Dynamics of tick-borne disease systems: minor role of recent climate change. Revue Scientifique et Technique 27, 367-381. See also presentation Marion Wooldridge Climate change and the pathogen challenge (http://www.mdaoa.ulg.ac.be/Conference/PDF/2009-Marion_Wooldridge.pdf). 14th conference on food microbiology, Liege, June 2009.
2-3	While conditions may become more favourable for incidental occurrence, the actual spread of diseases into epidemics is dependent on even more variables. For some diseases, we may consider epidemics as unlikely (i.e. trend estimate is zero). For other diseases, knowledge on e.g. the ecology and epidemiology is at present not sufficient to estimate this risk reliably.
3	Only a few indications, precise role of CC is still difficult to assess, and nature, extent, and tempo therefore difficult to judge.
	Data from other countries have to be extrapolate
	not sure about this, but there might be an increase
4	opinions

Food/water-borne: Food poisoning	
2	not specific for recent times; problem for decades
3	Temperature increase might increase disease risk (see cCASHh studies), but unclear whether this will really become a risk for the Dutch population (good hygiene, use of refrigerators etc)
	Clearly temperature related effect, but already possible to quantify a climate effect?
	Menne, B. and Ebi, K.L., eds. Climate Change and Adaptation Strategies for Human Health ed. WHO. 2006, Steinkopff Verlag Darmstadt: Darmstadt. All references mention potential effects of climate change on these health issues (i.e. increase in incidence of health effects), but the direct causal link with climate change is not obvious since there many are other factors. See also presentation Marion Wooldridge Climate change and the pathogen challenge (http://www.mdaoa.ulg.ac.be/Conference/PDF/2009-Marion_Wooldridge.pdf). 14th conference on food microbiology, Liege, June 2009.
	Probably more due to higher temperature
4	Many data, models for impact assessment exist, rough estimations could be made
	Large amount of data available, including time-series analyses on these infections related to temperature in Europe, particularly for Salmonella. What the effect of generally warmer temperatures (due to climate change) in specific countries/locations will be, may be less clear. Data should however be sufficient to make initial (rough) estimates.
	As long as the present standard of living persists, the impact will probably be nil (at least in The Netherlands)

Food/water-borne: Legionnaires Disease	
2	not specific for recent times; problem for decades
3	Temperature increase might increase disease risk (personal communication with AM de Roda Husman, RIVM), but unclear whether this will really become a risk for the Dutch population-> depends on water distribution systems infrastructure and adaptive capacity.
	Legionnaires Disease is mainly related to warm water systems. Some effect of warmer temperatures could be expected, but I am not sure whether the relative impact of climate change can be estimated.
	Clearly temperature related effect, but already possible to quantify a climate effect?
	Probably more due to higher temperature
4	Many data, models for impact assessment exist, rough estimations could be made
	As long as the present standard of living persists, the impact will probably be nil (at least in The Netherlands)

Food/water-borne: Contamination of swimming/recreation water	
No rating	yearly reports
3	Temperature/climate change might increase disease risk (personal communication with AM de Roda Husman, RIVM). Prevention of exposure (e.g. warning signs, swimming prohibited) not always in time or successful.
	Clearly temperature related effect, but already possible to quantify a climate effect?
	Probably more due to higher temperature. see information of conference Climate change and health, Oploopdebat ‘Klimaatverandering en Gezondheid’ Donderdag, 18 september 2008, door Kennis voor Klimaat Book: Mondiale milieuveranderingen en volksgezondheid o.a. Maud Huynen and Heatwaveplan 2008 on site www.rivm.nl
4	Many data, models for impact assessment exist, rough estimations could be made
	As long as the present standard of living persists, the impact will probably be nil (at least in The Netherlands)
	There is a large amount of (ongoing) research on this topic in the Netherlands; many data and models are available. These models however are known to have their limitations at present, but a rough estimation could be made.
	there is an increase, but I’m not sure of scientific research on this topic

Air quality: Respiratory problems due to ground-level ozone	
2	Clearly temperature related effect: but already possible to quantify a climate effect? Also countervailing effects.
2-3	This is a difficult one. In principle cause-effect relationships are known for ozone, NOx, PM. Increasing levels cause increasing health problems (mainly respiratory). However, if I interpret this question right it is about a secondary change caused by climate change. I believe we cannot say at the moment whether additional health problems arise due to this secondary effect. Simply because we do not even know the time-integrated sign of change of these substances due to climate change.
3	As the number of tropical days are expected to increase, the risk on ozone smog might increase as well (KNMI'06 scenarios brochure). However, this also depends on the future developments in the concentration ozone-precursors -> if these decrease (due to e.g. shift to electric cars) the risk on ozone decreases again.
4	Many data and models available. It is however difficult to estimate the effect of climate change on future ozone concentrations, as these are highly dependent on specific local conditions and changes, e.g. in weather and wind patterns.
	Many data and assessment models, tempo of ozone concentration increase is however difficult to assess, population vulnerability may also change (T-dependent)

	We know a lot about the exposure-effect relationship. However, I would think that, at least for the Netherlands and given the present standard of living, the effect would be minor.
5	reports and literature
Air quality: Respiratory problems due to particulate matter	
2-3	This is a difficult one. In principle cause-effect relationships are known for ozone, NOx, PM. Increasing levels cause increasing health problems (mainly respiratory). However, if I interpret this question right it is about a secondary change caused by climate change. I believe we cannot say at the moment whether additional health problems arise due to this secondary effect. Simply because we do not even know the time-integrated sign of change of these substances due to climate change.
3	Clearly temperature related effect, but already possible to quantify a climate effect?
4	Many data and assessment models, tempo of ozone concentration increase is however difficult to assess, population vulnerability may also change (T-dependent)
	Many data and models available. It is however difficult to estimate the effect of climate change on future PM concentrations, as these are highly dependent on specific local conditions and changes, e.g. in weather and wind patterns.
	We know a lot about the exposure-effect relationship. However, I would think that, at least for the Netherlands and given the present standard of living, the effect would be minor.
5	reports and literature
Air quality: Air quality-related cardiovascular problems	
3	Clearly temperature related effect, but already possible to quantify a climate effect?
4	Many data and assessment models, tempo of ozone concentration increase is however difficult to assess, population vulnerability may also change (T-dependent)
	Many data and models available. It is however difficult to estimate the effect of climate change on future ozone and PM concentrations, as these are highly dependent on specific local conditions and changes, e.g. in weather and wind patterns.
	We know a lot about the exposure-effect relationship. However, I would think that, at least for the Netherlands and given the present standard of living, the effect would be minor.
5	reports and literature

Flood/storm: Flood-related mortality	
2	As far as I know we don't have records including health problems related to flood changes caused climate change. Secondly, flood intensity depend on many non-climatic aspects, which most likely dominate climate change. The same is true for storms.
3	see report Deltacomittee, rampenoefening Waterproof, najaar 2008 at http://www.platformoverstromingen.nl/waterproef
4	is expected to remain low due to good evacuation infrastructure (see publication by Hajat S, Ebi KL, Kovats S, Menne B, Edwards S, Haines A. The human health consequences of flooding in Europe and the implications for public health.....) climate change adaptation with regards to flood risk is already ongoing in the Netherlands in order to prevent actual flooding
4-5	Much research has been done on flooding risks, particularly related to amounts of deaths. Using such models, it would be possible to make scenario-based estimations of casualties and increases therein. However, such estimations depend on a daisy-chain of assumptions. They're estimations of what could happen, given a certain event, location, population at risk, etc. but not what would actually happen if such an event took place. Actual casualties depend on a great deal of less quantifiable variables, such as how people and emergency managers will respond, the level of disaster preparedness and people's self-reliance/self-organisation, the actual state of local water defences at the time, whether vulnerable people can get away, how early evacuations are started (dependent on e.g. how early a threat is recognized, how people respond, etc.), and any other factors that could enhance or dampen the effects (disasters are after all often due to the occurrence of multiple problems at the same time). I would therefore be sceptical about bound estimates of climate change impacts on flood mortality, although such estimates are better than

	‘order of magnitude’ estimates. They are somewhere in between.
5	Many data and models for impact assessment exist.
	Modelling data available
	Sufficient experience to rate the risk
Flood/storm: Flood-related infectious diseases	
2	While such infections have been reported in other countries, particularly in the developing world and during major disasters, it remains to be seen whether these would actually take place in a country such as the Netherlands (I do not know of any cases so far). It also depends on the effectiveness of emergency management, the ability of the healthcare system to spot infections (or the risk thereof), etc. Assessing the effect of climate change on increases in such infections is even more difficult.
	As far as I know we don’t have records including health problems related to flood changes caused climate change. Secondly, flood intensity depend on many non-climatic aspects, which most likely dominate climate change. The same is true for storms.
	For the Netherlands no knowledge; so only guesses from circumstantial evidence.
3	Only few data and models for impact assessment exist.
	depends on flood prevention ->climate change adaptation with regards to flood risk is already ongoing in the Netherlands in order to prevent actual flooding In case of flooding disease risk increases (see publication by Hajat S, Ebi KL, Kovats S, Menne B, Edwards S, Haines A. The human health consequences of flooding in Europe and the implications for public health.....). there is a good change on 'riooloverstorten' in case of flooding, increasing disease risk
	Reasoning and some data from abroad
Flood/storm: Flood-related exposure to dangerous substances and contaminants	
2	Effects might be expected, but substantial lack of data
	It could be that increasing floods and storm amount/intensity increases the risk of chemical spills, sewage overflows, etc. Whether these will actually result in people being poisoned (in a country such as the Netherlands) remains to be seen.
	As far as I know we don’t have records including health problems related to flood changes caused climate change. Secondly, flood intensity depend on many non-climatic aspects, which most likely dominate climate change. The same is true for storms.
	For the Netherlands no knowledge; so only guesses from circumstantial evidence.
3	depends on flood prevention ->climate change adaptation with regards to flood risk is already ongoing in the Netherlands in order to prevent actual flooding I'm not sure what guidelines are in place to prevent exposure in
	Reasoning and some data from abroad
Flood/storm: Flood-related respiratory problems	
2	As far as I know we don’t have records including health problems related to flood changes caused climate change. Secondly, flood intensity depend on many non-climatic aspects, which most likely dominate climate change. The same is true for storms.
	For the Netherlands no knowledge; so only guesses from circumstantial evidence.
3	Respiratory problems have been shown following floods in other countries, and dampness in homes is known to increase respiratory problems. One could expect climate change to increase this health risk, but the actual magnitude of this effect may be difficult to assess. Particularly the translation of increased flooding risks to additional home dampness and additional health effects for the Dutch situation specifically seems difficult. See e.g. Ayres et al., 2009. Climate change and respiratory disease: European Respiratory Society position statement. Eur Respir J 2009; 34:295-302.
	depends on flood prevention ->climate change adaptation with regards to flood risk is already ongoing in the Netherlands in order to prevent actual flooding in case of flooding, mold in damp houses are expected to cause health problems
	Reasoning and some data from abroad

4	Effects might be expected, but substantial lack of data, although there are extimations on current dampness situations in homes
Flood/storm: Flood-related mental health problems	
2	As far as I know we don't have records including health problems related to flood changes caused climate change. Secondly, flood intensity depend on many non-climatic aspects, which most likely dominate climate change. The same is true for storms.
3	Effects might be expected, but substantial lack of data
	Studies have shown mental health problems after floods (and even evacuations). A possible increase in flooding and evacuations would increase this health risk, but not enough data is available to make any estimates for future situations.
	see report Deltacomittee, rampenoefening Waterproof, najaar 2008 at http://www.platformoverstromingen.nl/waterproef
	In case of flooding, mental health problems, characterized as psychological distress, dominate the health impacts, being considerably greater than the combined physical symptoms (see publication by Hajat S, Ebi KL, Kovats S, Menne B, Edwards S, Haines A. The human health consequences of flooding in Europe and the implications for public health.....).
	For the Netherlands no knowledge; so only guesses from circumstantial evidence. But some evidence from other disasters.
4	Data from comparable disasters and other disasters are available
Flood/storm: Storm-related mortality and injury	
2	It is still unclear whether climate change will increase or decrease the frequency and intensity of storms.
	As far as I know we don't have records including health problems related to flood changes caused climate change. Secondly, flood intensity depend on many non-climatic aspects, which most likely dominate climate change. The same is true for storms.
	heavy storms occur more frequently
3	Effects might be expected, but substantial lack of data
	While the amount of storms is decreasing at present – climate change is expected to counter this trend. While changes are expected, these are relatively small and highly uncertain (but estimates have been made, e.g. in the KNMI'06 scenarios). While one could expect an increase in mortality/injury risk due to such changes, to my knowledge no data is available on the effect of such (relatively small) changes on mortality/injury in the Netherlands.
	see report Deltacomittee, rampenoefening Waterproof, najaar 2008 at http://www.platformoverstromingen.nl/waterproef
4	For the Netherlands no knowledge; so only guesses from circumstantial evidence. But more evidence from other disasters.
	reports
6	Data available that can be extrapolated

UV: Cataract	
1	I assumed that climate change did not include ozone layer depletion. Apart from intricate interactions between greenhouse effects and ozone layer depletion, I would not have any idea to which extent changes in UV exposure would attributable to climate change.
2	Much research is available on the health effects of UV radiation, but the knowledge on the effects of climate change on ozone depletion (hampering the recovery of the ozone layer) and UV exposure (changes in cloud cover, changes in behaviour due to warmer temperatures; e.g. spending more time outside) severely limit estimates. These are highly uncertain issues, which also strongly dependent on other factors (e.g. location, socio-economic factors, other climatic and weather conditions). Perhaps an expected sign can be suggested for the global situation, but I do not think that this is possible for the national scale.

	Besides warming climate change could lead to changes in cloudiness with unclear sign. The ozone layer is another actor influencing UV. It is unclear how climate change will affect the ozone layer. In addition, a non-climate change effect is a reducing level of air pollution (aerosol) due to policy measures. This may lead to increasing UV exposure.
5	Good data and models for impact assessment
	Data available from other countries which have a climate now, that we will possibly get in the future
	function of UV exposure (IARC data)lots of research from Australia
UV: Skin cancer	
1	I assumed that climate change did not include ozone layer depletion. Apart from intricate interactions between greenhouse effects and ozone layer depletion, I would not have any idea to which extent changes in UV exposure would attributable to climate change.
2	Much research is available on the health effects of UV radiation, but the knowledge on the effects of climate change on ozone depletion (hampering the recovery of the ozone layer) and UV exposure (changes in cloud cover, changes in behaviour due to warmer temperatures; e.g. spending more time outside) severely limit estimates. These are highly uncertain issues, which also strongly dependent on other factors (e.g. location, socio-economic factors, other climatic and weather conditions). Perhaps an expected sign can be suggested for the global situation, but I do not think that this is possible for the national scale.
	Besides warming climate change could lead to changes in cloudiness with unclear sign. The ozone layer is another actor influencing UV. It is unclear how climate change will affect the ozone layer. In addition, a non-climate change effect is a reducing level of air pollution (aerosol) due to policy measures. This may lead to increasing UV exposure.
3	due to more and stronger sun-radiation
4	the media tells us this is the case
5	Good data and models for impact assessment
	Data available from other countries which have a climate now, that we will possibly get in the future
	public health reports on the effects of more sun exposure
	function of UV exposure (IARC data)lots of research from Australia
UV: Weakening of the immune system	
1	I assumed that climate change did not include ozone layer depletion. Apart from intricate interactions between greenhouse effects and ozone layer depletion, I would not have any idea to which extent changes in UV exposure would attributable to climate change.
2	UV effects on the immune system have been suggested, but very little research has been done on this issue. Combined with the uncertainties in climatic effects on UV, to me, there does not seem to be enough information to estimate a trend.
4	Only indications but nature, extent and tempo of effects largely unknown.
5	Data available from other countries which have a climate now, that we will possibly get in the future

C.3. Uncertainties

This section lists the specific uncertainties which participants listed for health effects which they selected as most policy-relevant. These are in addition to arguments given for the 'level of precision scores' (*Appendix B.2.*).

Temperature: Heat-related mortality
difficulties in estimating future heat waves limited research into specific Dutch situation
Duration, severity and frequency of heat strokes. The feasibility from people to adapt.
Maud Huynen: information of conference Climate change and health, Oploopdebat 'Klimaatverandering en Gezondheid' Donderdag, 18 september 2008, door Kennis voor Klimaat Book: Mondiale milieuveranderingen en volksgezondheid o.a. Maud Huynen and Heatwaveplan 2008 on site www.rivm.nl
Health related mortality is only the top of the iceberg
Temperature: Heat-related cardiovascular problems
Nature, extent and tempo of impact unknown.
Temperature: Heat-related respiratory problems
Maud Huynen: information of conference Climate change and health, Oploopdebat 'Klimaatverandering en Gezondheid' Donderdag, 18 september 2008, door Kennis voor Klimaat Book: Mondiale milieuveranderingen en volksgezondheid o.a. Maud Huynen and Heatwaveplan 2008 on site www.rivm.nl
Temperature: Dehydration
Maud Huynen: information of conference Climate change and health, Oploopdebat 'Klimaatverandering en Gezondheid' Donderdag, 18 september 2008, door Kennis voor Klimaat Book: Mondiale milieuveranderingen en volksgezondheid o.a. Maud Huynen and Heatwaveplan 2008 on site www.rivm.nl

Allergies: Asthma
link between climate change, allergen release and allergen exposure limited research into specific Dutch situation
Gezondheidsraad 2008
Allergies: Duration of pollen season
New pollen types and allergenicity
Allergies: Pollen types, abundance and allergenicity
Nature, extent and tempo of impact unknown. Many other factors may also favor these sorts of effects, but the role of CC could be substantial.
Maud Huynen: information of conference Climate change and health, Oploopdebat 'Klimaatverandering en Gezondheid' Donderdag, 18 september 2008, door Kennis voor Klimaat Book: Mondiale milieuveranderingen en volksgezondheid o.a. Maud Huynen and Heatwaveplan 2008 on site www.rivm.nl

Vector-borne: Native vector-borne diseases
the complexity of the Lyme disease transmission cycle
complex disease ecology links with climate change unclear

Vector-borne: Incidents of non-native vector-borne diseases
Nature, extent and tempo of impact unknown. Many other factors may also favor these sorts of effects, but the role of CC could be substantial.
basic information on vector-species is lacking

Vector-borne: Epidemics of non-native vector-borne diseases
complex disease ecology interplay with other factors such e.g. trade and medical technology limited research into specific Dutch situation
Incidence, severity, survival of vectors
transmission of infectious diseases hopelessly complicated

Food/water-borne: Contamination of swimming/recreation water
Nature, extent and tempo of impact unknown. Many other factors may also favor these sorts of effects, but the role of CC could be substantial, on top on other factor like more water in urban areas etc.
Incidence; quantity of surface-water in summer season

Air quality: Air quality-related cardiovascular problems
Nature, extent and tempo of impact unknown. Many other factors may also favor these sorts of effects (world wide emissions increases), but the role of CC (T-increase in general, but also T extremes) could be substantial.

Flood/storm: Flood-related mortality
north sea storm tracks. Sea level much more certain (or at least bounded). And of course the engineered adaptation over the next decades is unknowable

Other: Societal disruption elsewhere
Uncertainties in economic development and governance structures

C.4. Arguments for relevance scores

This section lists the arguments given for selecting a particular health effect as 1st-5th most relevant for Dutch climate adaptation policy.

General comments
It is impossible to draw a list of most relevant effects without knowledge of all listed effects. Effects 5 and 6 are probably less relevant than the other effects. Effect n° 29 seems to be of minor importance (pers. comm. prof Professor Debby Guha-Sapir, CRED, 2009)
Health effects in the Netherlands are of minor relevance; it is better and much more efficient to aim resources at susceptible regions and populations, were real public health disasters can be expected.
It does not make sense to divide allergies or any of the other main categories in the different topics as indicated above. It is the combination of impacts that makes a topic an important issue. Given the large amount of uncertainties and lack of knowledge on the socio-economic and health impacts of each of the potential health impacts (allergies, pests, storms, etc.) it is not possible and useful to prioritize them. The respondents will mainly mention the topics they work on so the final prioritization depends on the number of people from each discipline that fill in the questionnaire. During the Oploopdebat Klimaatverandering en Gezondheid in autumn 2008 an overview was made of the main health topics and together with a large amount of stakeholders a begin was made with identifying the possible adaptation options and the role that each stakeholder has in the adaptation. For each topic a number of adaptation options can be mentioned but it would take too much time to describe them. Whether the different options will be effective is not known and no studies exist. [Scoring of health themes: 1. allergies, 2. vector-borne, 3. temperature, 4. food/water-borne, 5. pests]

Temperature: Heat-related mortality	
1	elderly homes/buildings in the Netherlands not adapted sufficient to extreme heat, especially problem in the cities
	The existing houses and the planning of cities and towns are completely not adapted to higher temperatures
	European population are not well adapted to quick temperature evolution
	Many people potentially at risk, possibility of large number of deaths at the same time.
	political interest poor state of nursing homes scattering of the help and health care system
2	all heat elated mortality AND disease public perception (see Paris 2003 heat wave) stress on the health care system
	typical responsibility of health care sector; and they don't have a clue (only interested in controlling health care costs)
Temperature: Heat-related cardiovascular problems	
3	Effects could be substantial
	traffic , city design and their related air quality situation and a high incidence of obesity and cardiovascular disease and diabetes
Temperature: Heat-related respiratory problems	
2	traffic , city design and their related air quality situation
4	elderly homes/buildings in the Netherlands not adapted sufficient to extreme heat, especially problem in the cities

Temperature: Heat-related stress and sleep disturbance	
1	people are tired during school and work in some time periods
Temperature: Dehydration	
2	elderly homes/buildings in the Netherlands not adapted sufficient to extreme heat, especially problem in the cities

Allergies: Asthma	
3	this is already affecting many people allergic asthma is already causing a considerable health burden climate change might add to this problem possible high economic impacts of disease (prevention) economic costs of chronic disease
5	number of children with asthma is still rising to epidemic proportions
Allergies: Duration of pollen season	
2	Huge number of people affected. While the health impacts per person aren't that severe, the cumulative impact (health and economical) is potentially very large.
	Number of inhabitants suffering
4	high occurrence of hay fever patients and the loss of working days
Allergies: Pollen types, abundance and allergenicity	
2	Effects could be substantial and difficult to adapt to.
3	elderly homes/buildings in the Netherlands not adapted sufficient to extreme heat, especially problem in the cities

Vector-borne: Native vector-borne diseases	
1	As Lyme is already present and therefore changes through climate change (- or +) are real and important to know
5	huge increase in disease risk (Lyme)observed in past 15 years high costs for treatment of chronic condition/ high disease burden is possible e.g. neurological effects
Vector-borne: Incidents of non-native vector-borne diseases	
1	Effects could be substantial and difficult to adapt to.
2	insects and ticks are directly affected by climate and therefore also its change
4	Incidents can be difficult to recognize, can be serious consequences and can result in public unrest.
Vector-borne: Epidemics of non-native vector-borne diseases	
1	public perception -> 'fright factors' health impact stress on the health care system possible high economic impacts of disease (prevention)
	low probability, high societal/economic impact... Risk perception
4	Already in southern countries that have the climate we will possibly get

Food/water-borne: Contamination of swimming/recreation water	
5	Effects could be substantial and difficult to adapt to (I have taken this somewhat broader to recreation water in general and non-streaming water left behind for long time.
	Lots of water together with recreation habits

Air quality: Respiratory problems due to ground-level ozone	
4	air pollution is already a considerable health problem in the Netherlands -> climate change might add to this
Air quality: Air quality-related cardiovascular problems	
4	Effects could be substantial and difficult to adapt to.

Flood/storm: Flood-related mortality	
1	politically sensitive, high likelihood, wide spatial extent and hence magnitude of events
3	Culturally very important in the Netherlands; the societal signal value of a single (potential) casualty due to flooding is very large. Also a large economic value at risk (immediate damage, damage to image of the country in the eyes of companies).
Flood/storm: Flood-related mental health problems	
2	Underlying stress for populations in hazard areas
5	Fairly under-recognized issue, but as such effects are noted even during evacuations, it is something that should be (and can be) taken into account.
Flood/storm: Flood-related exposure to dangerous substances and contaminants	
3	Could be widespread exposure. Highly politically sensitive as blame would fall on those who contaminated rivers and urban areas originally. But highly uncertain.

UV: Skin cancer	
3	Cultural habits of sun bathing

Other: Societal disruption elsewhere	
1	Societal disruption elsewhere will also affect our health

C.5. Policy options

This section lists the policy options that respondents considered either robust or vulnerable to the uncertainties associated with the particular health effect. Respondents were asked to provide these for the effects they selected as most relevant.

Temperature: Heat-related mortality
heat health warning system with clear responsibilities for relevant actors, based on scientific results concerning risk conditions and adaptation options planning to avoid urban heat island building regulations, e.g. for nursing homes the elderly, the chronically ill (CVD and respiratory) and small children perhaps other diseases are also risk factors like diabetes or renal disease, but limited scientific research on these findings
see heatwave plan on www.rivm.nl
Modelling of climate change. Policy measures like water in building environment, information to the people how to cope with heat.
Contingency planning (i.e. what to do in case of severe heat) at various levels, ranging from national to local, including heat plans for health care institutions. Information and education of vulnerable groups and those who care for vulnerable groups (e.g. employees in elderly care). Heat robust building design and city planning (e.g. parks, wind corridors, etc.) could be an option as well, although the costs would need to be considered.
provide tips on public broadcasting (focus on elderly) on how to stay cool in heatwave situation
alert health care
Temperature: Heat-related cardiovascular problems
Monitoring and surveillance, early warning, data collection, development of models for scenario calculation and impact assessment, medicine production increase, need for more cooling (indoor, outdoor), link with urban design, better health care
prevent summer smog
Temperature: Heat-related respiratory problems
see heatwave plan on www.rivm.nl
in smog periods prevent mixture of alcohol in fuel it worsens the situation dramatically
Temperature: Dehydration
see heatwave plan on www.rivm.nl

Allergies: Asthma
monitoring, warning systems, timely medication, natuurbeheer
Allergies: Duration of pollen season
Information supply to hay fever patients. Taking hay fever into account when selecting plants for public green spaces.
Information and medicine
take care in designing gardens and parks and the use of plants in a city environment

Allergies: Pollen types, abundance and allergenicity
Monitoring and surveillance, early warning, data collection, development of models for scenario calculation and impact assessment, medicine production increase, maybe low allergic green zones etc.
see heatwave plan on www.rivm.nl

Vector-borne: Native vector-borne diseases
avoid tick bites and remove attached tick as soon as possible to prevent disease
monitoring and warning systems risk communication not always effective in changing risk behavior risk groups: people spending time outdoors (recreative), boswachters
Vector-borne: Incidents of non-native vector-borne diseases
Monitoring and surveillance, early warning, data collection, development of models for scenario calculation and impact assessment, vaccine and other medicine production increase, hygiene adaptation measures.
basic surveillance activities for vectors
Not vulnerable to uncertainties: education of health professionals, monitoring, designing flexible contingency plans in cooperation with countries in which diseases are prevalent or appear incidentally. Ideally, generic contingency plans should be available to deal with unexpected or unknown diseases and incidents. Vulnerable to uncertainties: pre-emptive vaccination strategies (high risk of over-investment plus potential adverse health consequences) or storing huge stockpiles of vaccines (high risk of over-investment). Designing very specific plans only for diseases and scenarios/transmission routes, etc. that seem likely candidates to appear incidentally in the Netherlands is not a good idea. These cannot deal with surprises.
Vector-borne: Epidemics of non-native vector-borne diseases
monitoring and early response? vaccination
Literature and survey what happens elsewhere
good surveillance

Food/water-borne: Contamination of swimming/recreation water
Monitoring and surveillance, early warning, data collection, development of models for scenario calculation and impact assessment, link with urban design, better health care and information to the public
Information, good distribution of surface water

Air quality: Respiratory problems due to ground-level ozone
air pollution control measures risk group: respiratory patients
Air quality: Air quality-related cardiovascular problems

Monitoring and surveillance, early warning, data collection, development of models for scenario calculation and impact assessment, link with urban design, better health care

Flood/storm: Flood-related mortality
Improving water safety in general using a combination of approaches aimed at reducing flooding probability as well as potential consequences. Good evacuation strategies and monitoring. Prediction-based hard engineering approaches are vulnerable to the uncertainties. Particularly e.g. overdimensioning dikes, which entails high risks of overspending as well as increasing vulnerability (if the predictions turn out to be incorrect, those behind the dikes are at greater risk).
hard engineering makes the risks more unpredictable and means that any event could be more catastrophic in the end
Flood/storm: Flood-related mental health problems
Contingency planning, training of disaster recovery personnel as well as general practitioners (making sure they recognize the signs) and mental health professionals. Since mental health problems have been reported following only evacuations (that didn't include actual flooding, damage, casualties, etc.), this aspect should be included in evacuation planning.

UV: Skin cancer
information

Other: Societal disruption elsewhere
Present political trends all hamper adaptation. Societal change or transition is needed.

C.6. Other comments

[*Other health effects of climate change*:] Muggen brengen nu nog geen ziekten over maar zijn al wel heel vervelend. Verwacht wordt dat het actieve seizoen langer zal worden en dat de aantallen muggen zullen toenemen in ons land. Zie http://www.natuurbericht.nl/default.asp?cat=&id=1548 en het daar genoemde rapport van Verdonschot. De overlast zal verder toenemen indien ook muggensoorten als de Tijgermug zich in ons land gaan vestigen. Deze mug steekt veel venijniger dan de muggen die we al in ons land hebben en ze steken ook nog eens overdag. 'Onze' muggen doen dat niet of nauwelijks. De kwaliteit van leven voor grote aantallen mensen zal substantieel afnemen (ook nachtrust) zeker als er ook de dreiging van ziekten bijkomt.
Climate change is of very limited relevance for Dutch public health (if any). It is much better (and much more efficient) to invest money and capacities to mitigate health consequences in the more susceptible regions and populations in the world.
I know there are/will be less bees.
especially for the most vulnerable people (like lonely elderly) climate change will have a negative effect
No other effects, but some effects will be more severe for the group of workers in the field or for the elderly people.
[*Other health effects of climate change*:] flash flooding sewerage overflow and exposure to pathogens molds increase in indoor air quality
The effects due to social disruption of societal structures, possibly elsewhere, were not included and in my view present the greatest risks.

Appendix D. Summaries of approaches

These summaries were provided for the PBL & WHO workshop 'Policy options for climate change and health', Bonn, 11-12 February 2010. The first section deals with the approach of this study, the second section deals with the policy implications of the results.

Expert survey regarding uncertainty

In 2009, an expert-survey was held on climate change, health and uncertainties in the Netherlands. The purpose of the study was to examine the levels of uncertainty regarding the health effects of climate change, to judge the relevance of each potential health effect for the Netherlands and to reflect on the implications of uncertainty for climate change adaptation. The survey used a shortlist of 33 climate change related health issues on the themes: temperature, allergy, pests, vector-borne diseases, food- and water-borne diseases, air quality, flooding and storm, and UV.

During the first (and main) part of the survey, the level of uncertainty regarding each health issue was explored. Given the present state of knowledge, experts were asked to indicate the 'level of precision' with which science is able to estimate the magnitude of the health risk of each health issue. A 'level of precision' scale was used, as indicated in Table 1. Respondents were also asked to provide a brief argumentation and, if possible, some literature references. The argumentation was used to analyze the lines of reasoning leading to the scores and to explain differences in scores between the experts.

During the second part of the survey, experts were asked to select the five most relevant health issues (from the shortlist) for climate change adaptation in the Netherlands. They were asked to take into account not only the health impact, but also e.g. public and political perception and the availability of options for adaptation and control. These selections were translated into total scores for each health issue. Following each score, respondents were asked to provide an argumentation for the score, some additional information on specific uncertainties regarding this health effect, and some initial ideas on which adaptation strategies would be either well-capable of dealing with the uncertainties or very vulnerable to them.

Table 10. Levels of precision (based on: Risbey en Kandlikar, 2007; Slottje et al., 2008).

Rating:	Label:	Description:
1	Effective ignorance	Knowledge of the factors that govern this effect is so weak that we are effectively ignorant.
2	Ambiguous sign or trend	Some effect is expected, but its sign or trend is not clear. There are plausible arguments either direction (effect could be positive, could be negative; could increase or decrease).
3	Expected sign or trend	It is clear what the sign and trend of the effect will be. However, there is no plausible or reliable information on how strong it will be.
4	Order of magnitude	It is possible to give a rough indication of the magnitude of the effect, a qualitative scoring (e.g. 1-10 scale), or a rough comparison with other effects.
5	Bounds	It is possible to estimate the bounds for the distribution of the effect, e.g. its 5/95 percentiles (effect is only 5% likely to be more than … and only 5% likely to be less than …). However, the shape of the distribution, or best-guess estimates, cannot be provided.
6	Full probability density function	It is possible to provide a full probability density function; the bounds as well as the shape of the distribution.
N/A	Don't know / no answer	

Expert survey on adaptation options and strategies (at WHO workshop)

The basic premise of examining the levels of uncertainty and the relevance of health effects for adaptation is that these have implications for the selection of policy strategies. For instance, a traditional risk approach would require information on both the magnitude of the health impact and its chances, i.e. a 'full probability density function' of the health risk. It cannot deal very well with ignorance. A resilience approach, on the other hand, is quite capable of dealing with effects that can be estimated only as 'expected sign or trend' or even an 'ambiguous sign or trend'. Along similar lines, the more policy-relevant an effect is, whether due to large health impacts or public perception, the more costly and extensive the policy options that can be considered. In addition, if a health effect is highly relevant and/or can be estimated with a high level of precision, it would be easier to argue for policy options targeting that health effect specifically. For options with low relevance and/or precision, more generic or holistic options could be considered. See Table 2 for a quick sketch.

Whether various strategies and options for various health effects are useful in a given situation, country or region therefore depends on a number of characteristics. Examples include: whether they are prediction- or system-oriented (e.g. resistance vs. resilience), are costly or extensive, have auxiliary benefits, are generic or specific for a health effect, et cetera. The aim for the WHO workshop would be to evaluate the list of options generated there on a number of such characteristics. The exact list of characteristics has yet to be determined, but can be based on an evaluation framework already developed at the Netherlands Environmental Assessment Agency (PBL)[9]. The evaluation method could consist of a rating on scales such as: 1-10 scales, yes/no, (strongly) disagree – (strongly) agree, etc., followed by discussion. In addition, some form of discussion of evaluation of the implications (i.e. considering uncertainty, relevance, and the characteristics, what could be considered promising approaches?) could be considered. However, large differences between countries/regions are to be expected.

Table 11. Uncertainty, relevance and policy options/strategies.

	Low relevance	High relevance
High level of precision (low level of uncertainty)	Tailored/prediction-based strategies (e.g. risk approach) are feasible. Focus on options with low costs or important auxiliary benefits.	Tailored/prediction-based strategies (e.g. risk approach) are feasible. Consider costly and extensive options.
Low level of precision (high level of uncertainty)	Enhance the system's capability of dealing with changes, uncertainties and surprises (e.g. resilience approach). Focus on options with low costs or important auxiliary benefits.	Enhance the system's capability of dealing with changes, uncertainties and surprises (e.g. resilience approach). Consider costly and extensive options.

	Low relevance	High relevance
High level of precision (low level of uncertainty)		Options can be highly specific for the health effect.
Low level of precision (high level of uncertainty)	Options are preferably fairly generic, reducing a range of health effects, rather than a specific one.	

[9] The PBL evaluation framework includes characteristics such as resistance, resilience, adaptive capacity, flexibility, indirect effects, time aspects, justice, etc.