MILJØMINISTERIET

MINISTRY OF THE ENVIRONMENT
ENVIRONMENTAL PROTECTION AGENCY

Valuation of Chemical Related Health Impacts

Estimation of direct and indirect costs for asthma bronchiale, headache, contact allergy, lung cancer and skin cancer

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Environmental Project **Nr. 929** 2004
Miljøprojekt

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1 Dansk resumé

Formålet med projektet er at estimere enhedsomkostningerne for udvalgte kemikalierelaterede sygdomme. Værdierne tænkes anvendt i forbindelse med samfundsøkonomiske analyser på kemikalieområdet.

Enhedsomkostningerne skal afspejle omkostningerne for hele samfundet ved et tilfælde af en given sygdom. Dette inkluderer således både de direkte omkostninger i form af omkostninger ved behandling samt de indirekte omkostninger, der omfatter såvel produktionstabet som det individuelle velfærdstab.

Fokus i projektet er estimering af de direkte omkostninger, som suppleres med skøn for produktionstabet og velfærdstabet.

De udvalgte sygdomme er:
- Astma
- Hovedpine
- Kontaktallergi
- Lungekræft
- Hudkræft

Metode
De direkte omkostninger estimeres på basis af publicerede studier og anden tilgængelig information suppleret med ekspertvurderinger. De direkte omkostninger omfatter de offentlige udgifter i forbindelse med behandlingen. Patienternes eventuelle egenbetaling er ikke inkluderet, da denne del er inkluderet i det individuelle velfærdstab.

Det individuelle velfærdstab estimeres på basis af benefit transfer fra eksisterende betalingsvilligheds-studier. Her korrigeres for pris- og købekraftsforskelle i forbindelse med anvendelse af studier fra andre lande.

Produktionstabet beregnes ved brug af den gennemsnitlige primærindkomst per person i og uden for arbejdsstyrken.

Astma
Kemikalier kan udløse astmaanfald for astmapatienter, men fører kun i sjældne tilfælde til udløsning af sygdommen som sådan. Derfor er fokus på enhedsomkostningen for et astmaanfald. Dette suppleres med en eksempelberegning, hvor livstidsomkostningerne estimeres for en patient, der har 3 årlige astmaanfald.

Enhedsomkostningen per astmaanfald beregnes til knap 2.000 kr. hvoraf de direkte omkostninger udgør ca. 420 kr., velfærdstabet knapt 1.200 kr. og produktionstabet ca. 390 kr.

Hovedpine
Der findes meget lidt evidens omkring sammenhængen mellem kemikalier og hovedpine. Her vurderes enhedsomkostningen ved et moderat tilfælde af hovedpine, defineret som en dag karakteriseret ved " en dag med to episoder

af smertende hovedpine, hver af en varighed på 2 timer". Denne suppleres med en eksempelberegning af omkostinger for et scenario, hvor en patient har 10 hovedpinetilfælde inden for et år (omkostningen inkludere stillelse af diagnosen).

Enhedsomkostningen per tilfælde hovedpine beregnes til godt 360 kr. Heraf udgør de direkte omkostninger stort set ingenting (1,30 kr.), mens velfærdstabet og produktionstabet begge udgør ca. 180 kr.

Kontaktallergi
En lang række kemikalier kan medføre kontaktallergi, som er en kronisk lidelse. Enhedsomkostningerne beregnes over patientens fulde restlevetid under antagelse om en gns. alder på 40 år ved sygdommens indtræden og en årlig diskonteringsrate på 3 pct.

Enhedsomkostningen for kontaktallergi over hele restlevetiden beregnes til ca. 290.000 kr. Heraf udgør de direkte omkostninger godt 40.000 kr., velfærdstabet godt 230.000 og produktionstabet ca. 20.000 kr.

Endvidere gives et eksempel på enhedsomkostningernes anvendelse ved en illustrativ beregning af de sundhedsmæssige gevinster ved forbud mod nikkel i udvalgte produkter vedtaget i 1989.

Det antages at lovgivningen har medført en reduktion i tilfældene af nikkelallergi på 2.500 årligt (steget lineært fra 0 til 2500 over de første 5 år).

Beregningen foretages for en tidshorisont på 20 år. Ved anvendelse af enhedsomkostningen for kontaktallergi resulterer dette i nutidsværdi for de samlede gevinster på godt 9,7 mia. kr.

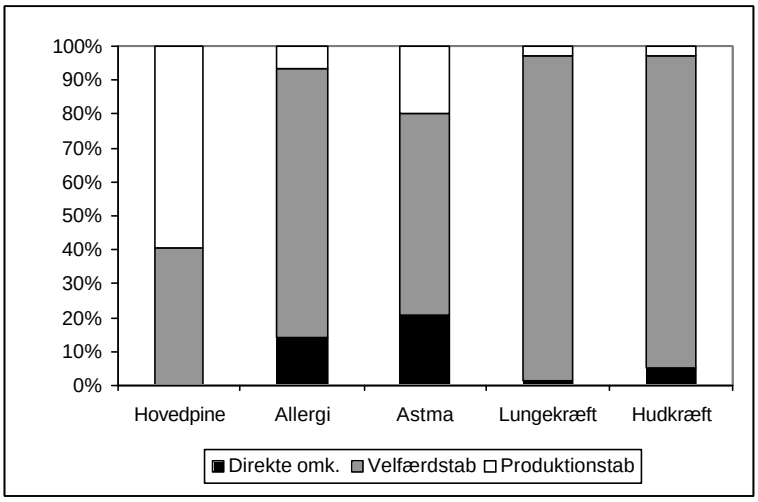
Lungekræft
Selvom rygning er ansvarlig for langt størstedelen af tilfældene af lungekræft, kan en række kemikalier også være medvirkende til sygdommen. Dødeligheden blandt patienterne er relativt høj. Patienternes sygdomsforløb estimeres ved en Markov-model og på basis heraf beregnes omkostningerne. Det antages at patienterne i gennemsnit er 50 år ved sygdommens indtræden samt en diskonteringsfaktor på 3 pct.

Enhedsomkostningen per tilfælde lungekræft beregnes til ca. 9,7 mil. kr. De direkte omkostninger udgør godt 140.000 kr., mens velfærdstabet er den væsentligste omkostningskomponent af størrelsesordnen ca. 9,3 mil. kr. Produktionstabet udgør godt 250.000 kr.

Hudkræft
Dyrestudier og epidemiologiske undersøgelser tyder på at visse kemikalier kan øge risikoen for kræft. Sygdommen er her afgrænset til ikke malin hudkræft, som er langt mindre farlig end malin hudkræft (modermærkekræft). Patienterne behandles normalt inden for et år.

Enhedsomkostningen per tilfælde hudkræft beregnes til omkring 250.000 kr., hvoraf de direkte omkostninger udgør omkring 12.000 kr., velfærdstabet ca. 230.00 kr. og produktionstabet knapt 7.000 kr.

De samlede omkostningsestimater
Omkostningsestimaterne er sammenlignet i figuren nedenfor. Det ses at velfærdstabet generelt udgør langt den største omkostningskomponent. Denne omkostningskomponent er samtidigt den langt mest usikre.



Vurdering af usikkerheden på omkostningsestimaterne
Udover de beregnede omkostningsestimater er der opstillet højt og lavt skøn for hvert omkostningsestimat. Disse kan opfattes som skøn svarende til henholdsvis 5 % og 95 % fraktilerne for enhedsomkostningen.

Estimeringen af de lave og høje skøn er baseret på en forholdsvis overordnet vurdering foretaget af konsulenten frem for en matematisk estimering af de respektive fraktiler. Fremgangsmåde er som følger: Først identificeres de kritiske parametre ud fra kriterierne vigtighed og grad af usikkerhed. Dernæst gives skøn på lave og høje værdier for de parametre identificeret som værende vigtige og/eller meget usikre.

På basis af de opstillede parameterværdier udregnes de lave og høje skøn. Resultatet bliver følgende bånd for omkostningsestimaterne:
Astma: 900 kr. - 2.600 kr.
Hovedpine: 200 kr. - 600 kr.
Kontaktallergi: 79.000 kr. - 690.000 kr.
Lungekræft: 1,8 mil. kr. - 11,8 mil. kr.
Hudkræft: 28.000 kr. - 519.000 kr.

2 English summary

The purpose of the project is to estimate the unit costs of selected chemical related diseases. The estimates are expected to be used in connection with economic analyses in the area of chemicals.

The unit costs shall reflect the costs for the entire society following a case of the given disease. Therefore, the unit costs include the direct costs in terms of costs of treatment as well as the indirect costs in terms of the production loss and the individual welfare loss.

Focus in the present project will be on a detailed estimation of the direct costs supplemented with more rough assessment of the indirect welfare loss based on benefit transfer of key values.

The selected diseases are:

- Asthma
- Headache
- Contact allergy
- Lung cancer
- Skin cancer

Method

The direct costs are estimated on the basis of published studies and other available information supplemented by expert judgements. The direct costs include the public costs in connection with the treatment. Possible own payment from the patients is not included since it is included in the individual welfare loss estimate.

The individual welfare loss is estimated by benefit transfer from existing willingness-to-pay studies. The values are corrected for differences in prices and purchasing power in connection with benefit transfer from foreign studies.

The production loss is estimated by the average primary income per person in and outside the Danish working force.

Asthma

Chemicals may release asthma attacks for asthma patient but does only very rarely release the disease itself. Following this, focus is on the unit cost of a single asthma attack. This is supplemented by an example calculation of the total lifetime costs for a patient who has 3 attacks a year.

The unit cost per asthma attack is estimated to a little less than DKK 2,000, where the direct costs amount app. DKK 420, welfare loss app. DKK 1,200 and the production loss app. DKK 390.

Headache

Only very little evidence regarding the relationship between chemicals and headache exists. In the present project, the unit cost of a moderate case of headache is estimated, defined as "two painful and splitting headaches during

the day. Each period of headache will last two hours". This is supplemented by a cost example of a patient experiencing 10 days of headache during a year (including the costs of diagnosis settlement etc.).

The unit cost per episode of headache is estimated to a little more than DKK 360. Of this, the direct costs amount to practically nothing (DKK 1.30), while the welfare loss and the production loss each amount to around DKK 180.

Contact allergy
Various chemicals may result in contact allergy, which is a chronic disease. The unit cost is estimated over the full remaining life time of the patient under the assumption of an average age of 40 years when the disease occurs and a yearly discount factor of 3%.

The unit cost of contact allergy over the entire remaining life time is estimated to app. DKK 290,000. The direct costs amount a little more than DKK 40,000, the welfare loss around DKK 230,000 and the production loss DKK 20,000.

Furthermore, an example of the use of the unit cost estimates is given by an illustrative estimation of the health related benefits of the prohibition against nickel in selected products agreed upon in 1989.

It is assumed that the regulation has resulted in a reduction in nickel allergy of 2,500 cases per year (increased linearly from 0 to 2,500 during the first 5 years of the prohibition).

The calculation is carried out for a time horizon of 20 years. By utilising the unit cost for contact allergy this results in a present value for the benefits of app. DKK 9.7 billion.

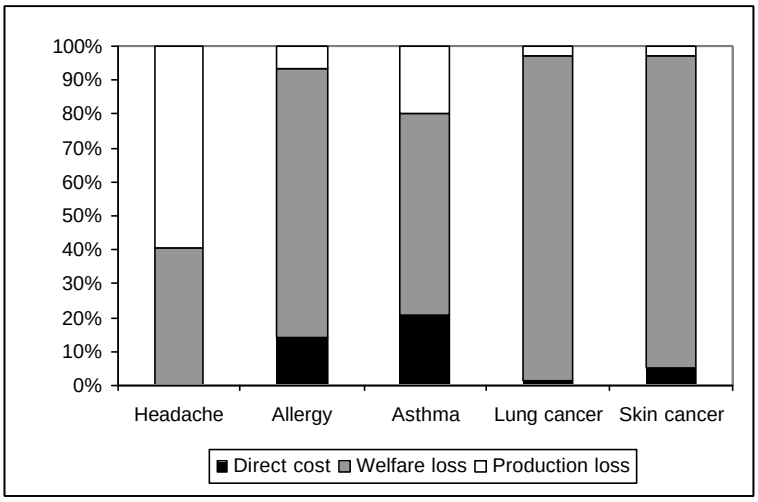
Lung cancer
Even though smoking is the main reason for the majority of the cases of lung cancer a number of chemicals may cause the disease as well. The mortality rate among the patient is rather high. The disease course is estimated by a Markov model and based on this the costs are estimated. It is assumed that the average age of the patient by the occurrence of the disease is 50 years along with a discount rate of 3% p.a.

The unit cost per case of lung cancer is estimated to app. DKK 9.7 m. The direct costs amount to around DKK 140,000, while the welfare loss is the most important component with a size of more about DKK 9.3 m. The production loss amounts to around DKK 250,000.

Skin cancer
Animal studies and observational human studies indicate that exposure to certain chemicals increases the relative risk of skin cancer. The disease is here limited to non-melanoma skin cancer, which is far less serious than melanoma skin cancer (birthmark cancer). The patients are normally treated within a year from the occurrence of the disease.

The unit cost per case of skin cancer is estimated to around DKK 250,000, of which the direct costs amount app. DKK 12,000, the welfare loss app. DKK 230,000 and the production loss a little less than DKK 7,000.

Summary of the unit cost estimates
The cost estimates are compared in the figure below. In general, it is seen that the welfare loss is the far most important cost component. At the same time, this cost component is far the most uncertain.



Assessment of the uncertainty of the cost estimates
Besides the unit cost estimates a low and high estimate is provided. These can be interpreted as estimates corresponding to the 5 and 95%percentiles respectively.

The estimation of the low and high estimates is based on a rather overall assessment performed by the consultant instead of a mathematic estimation of the percentiles. The method is as follows: First, the main critical parameters are identified from the criteria of importance and degree of uncertainty. Next, estimates of low and high values of the parameters identified as very important and/or very uncertain are given.

On the basis of these parameter values the low and high estimates are established. The result is following range for the unit cost estimates:
Asthma: DKK 900 - 2,600
Headache: DKK 200 - 6000
Contact allergy: DKK 79,000 - 690,000
Lung cancer: DKK 1.8 m. - 11.8 m.
Skin cancer: DKK 28,000 - 519,000.

3 Introduction

Economic assessment of environmental issues is a common used tool in the political environmental prioritisation process. Economic valuation of environmental and health related issues is one of the core inputs for such assessments.

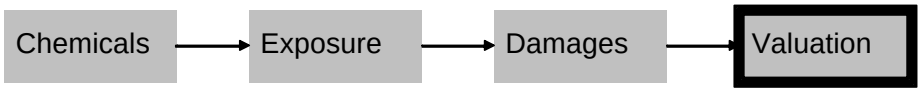
In the area of chemical reduction, most economic assessments only consider the cost side of a reduction initiative (that is, cost effectiveness analysis). The reason for this is that the environmental and health effects are difficult to quantify and especially to translate into a value that can be compared with the costs.

Thus, an important step towards an improvement of economic assessment of chemical reduction initiatives will be to provide values for the benefits attained by reducing the exposure to chemicals.

The purpose of this study is to provide economic values for a selected number of chemical related health impacts. It is the intention that these values - or unit prices - can be used as input in economic assessment of various potential chemical reduction initiatives. It is important to stress that the main focus of this study is on:

- Estimation of prices to be used when the number of diseases has been estimated;
- Estimation of the direct costs (medicine, hospital care etc), while the welfare loss is not detailed assessed, just included for having the total price.

Below, the impact path is illustrated. This project only considers the price of given damages in terms of specific diseases. There is a lot complications attached to the estimation of the number of diseases, as the impact path from emission of chemicals to exposure to damages is characterised by complex interactions between many factors.



The values are to reflect the incremental price for the society following a certain health impact. This means that both direct and indirect cost related to the disease are included, although focus in the present study has been on the development of direct costs. Although the direct costs often accounts for a small share of the total costs, having a solid estimate of this element will be very useful. It reduces the total uncertainty about the valuation and it provides important information about the share of costs related to various public budgets.

Assessment of the welfare element is complicated and significant improvement would require quite comprehensive analysis which has been out of scope for this study. Instead, the welfare cost element has been based on existing data sources and it has been chosen to use the same values as used in

a number of valuation studies commissioned by the Danish Ministry of Environment; thereby consistence is secured.

The elements included in the estimates are further described in Chapter 2 on valuation methodology.

Costs are reported in DKK as it is a Danish study. € 1 is equal to 7.44 DKK (2003). Furthermore, costs for each component are reported with accuracy of one DKK as they are used in subsequent calculations, despite the uncertainty level of the estimates. Finally, in Chapter 10, the uncertainty of the unit costs estimates is assessed.

Many sources have been used to compile the study. To the extent that international results have been used, their relevance in a Danish context has been evaluated. These evaluations have been made in cooperation with experts from each field of specialisation. The expert assessments are obtained from the persons listed in Appendix 2.

The present report documents the estimation of unit prices for five selected diseases: Asthma, headache, contact allergy, lung cancer and skin cancer. The diseases have been selected by DEPA and COWI in cooperation from the criteria of the relevance in relation to chemicals as well as the data availability. Chapter 2 describes the overall valuation methodology applied in the study. Next, each disease is considered separately in the chapters 3-7, including estimation of each cost component to be included in the unit cost estimate. Chapter 8 summarises the results, assesses the uncertainty of the estimates by providing high and low estimates and conclude on the findings. Along with this, it is illustrated how the estimates may be used in an economic assessment relation by an example of nickel allergy.

4 Valuation Methodology

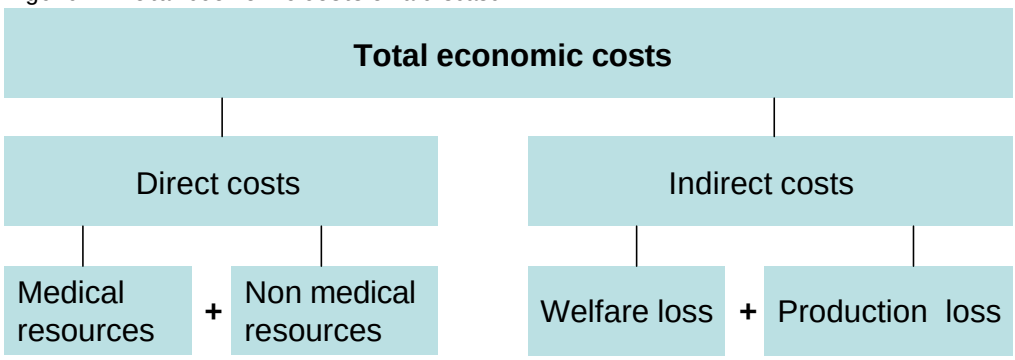
The objective of the study is to develop unit costs for the selected diseases that can be used in social cost-benefit analyses.. Therefore, it is the the total costs of the disease, and not only the direct costs, that has to be measured.

The unit prices for each disease are to reflect the average incremental costs due to the disease. In the estimate co-morbidity costs (increased likelihood of acquiring other diseases when having one disease) are also included.

In general, when assessing the total costs of a disease, the resources used should be valued at their opportunity costs (Brouwer et al. (2001)). This ensures that the cost estimate can be appropriately used in cost-benefit analysis. However, in health care markets, prices do often not reflect opportunity cost. The reason for this is market failures and the fact that payment is often fully or partially done by third party payer. In practice, however, it is difficult to assess the degree to which the available prices do not reflect opportunity costs. Therefore, correction of bias relation in the available prices will not be attempted.

The total economic costs of a disease consist of both direct and indirect costs (Figure 4-1). Direct costs are costs of medical and non-medical resources directly related to treatment of the disease. Indirect costs are the costs of the welfare and production loss related to the disease.

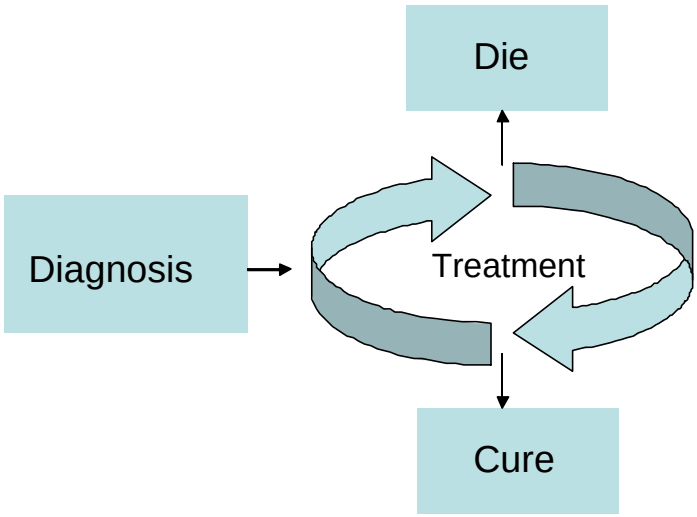
Figure 4-1 Total economic costs of a disease



As already mentioned, it is the assessment of the direct cost that is in focus in this study. Based on collection of specific data for the resource use and unit costs for individual elements in the medical and non-medical treatment of specific disease, it is possible to provide robust estimates of the direct costs. Only some elements like hospital costs have been assessed before, while a systematic overview of all direct cost elements for a given disease is the main contribution of this study.

The basis for valuation of the economic costs of the selected diseases will be a description of the disease course defined by a number of stages, each characterised by different costs (see Figure 4-2).

Figure 4-2: Illustration of a Disease course



The costs can be estimated either by assessing the costs at each state along with the probability of reaching the state or by estimating the costs of the total course aggregated. What approach to apply will depend on the data availability within each disease and within each cost element. The approach applied in the specific case is described in more detail in the following chapters.

The description of the valuation methodology is introduced by a section on the general issues of valuation method concerning in principle all cost elements. Next, each of the cost components of Figure 4-1 is described in details along with suggestion for the best valuation methodology for the present purpose.

4.1 General issues related to valuation methodology

The overall valuation framework will follow the guidelines of the Danish Ministry of Environment and the Danish Ministry of Finance found in Møller F. et al (2000) and Finansministeriet (1999) respectively. In addition to this, the following issues are highlighted below.

4.1.1 Discounting

Discounting is used in order to take into account that the costs will occur in different time periods. DEPA generally recommends a discount rate of 3%[1], whereas the Danish Ministry of Finance recommends that a 6% discount rate is used in cost-benefit analyses (Finansministeriet 1999). In the present study, a discount rate of 3% will be applied along with a sensitivity analysis using 6% instead of 3%.

4.1.2 Uncertainties

Costs are calculated for the average patient. In order to take uncertainty of the estimated costs and intensity of treatment into account low and high estimates will be provided along with the best estimate. Ideally, the low and high estimates are to reflect the 5 and 95 percent quartiles of the best estimate.

[1] Including a correction factor for capital investments (see Møller (2000))

These estimates are based on heretic assessments of possible lower and higher costs. The reason for the heretic assessment is that exact calculation of a specific quartile is not possible within the scope of the present project.

4.1.3 Age distribution and implication on the estimates

It is a currently ongoing discussion whether the size of production loss and individual welfare loss is age dependent (see sections 4.3 and 4.4 for further information of the points of discussion). In the present study, it is assumed that the cost elements are age independent.

For chronic diseases such as contact allergy, the calculation is based on an assumption of starting age of the disease and average remaining lifetime.

4.2 Direct costs

Direct costs are costs for medical resources and non-medical resource. Medical resources are costs for medical services needed for the treatment; i.e. hospital services, drugs, medical specialists, GPs (General Practitioners), nursing home, home help services, etc. Non medical resources are costs for non medical services needed for the treatment; i.e. transportation, worker retraining, acquisition of special equipment. In the estimate of direct costs, only costs of medical resources are included.

4.2.1 Methods estimation of direct costs

Lifetime costs for a disease or components of a disease can be estimated from either prevalence based annual costs or incidence based costs (Hudgson (1994))[2]. Roughly speaking, prevalence based lifetime costs are estimated by dividing total annual costs with the number of persons having the disease. Incidence based lifetime costs are estimated by modelling lifetime progression of the disease

The progression of the disease is either modelled using a simple probability tree or a Markov model. A Markov model is a way to model how a disease evolves over time (Briggs and Schulpher (1998)). From the Markov model, the expected lifetime costs can be directly estimated. The advantage to this method is that, that the costs are directly linked to the disease course. The main drawback is the detailed level of information required. For a further introduction to Markov models in a health care context see Briggs and Schulpher (1998) or Sonnenberg and Leventhal (1998).

In this report, the costs estimates are to be based on existing data. Therefore, the approach taken depends on the available data and can be different for the different cost components of the same disease. As a general rule, lifetime costs derived from the prevalence approach will often be more accurate than using the incidence approach when having poor estimates of important parameters (Hudgson (1994)). This is taken into account when choosing what method to apply.

[2] Lifetime costs can be estimated from the prevalence based annual costs when it is assumed that the parameters describing the prevalence, incidence and treatment of the disease are constant.

4.2.2 Data sources

Disease states

A disease consists of a number of disease states. Sources for classifying a disease into states are based on Danish, international publications and expert input.

Treatment within each disease state

The sources for treatment solutions within each disease state are based on Danish publications. Where no Danish publications are available, resource use is based on expert input by international acknowledged Danish physicians.

Expert input

The experts who have provided input are listed in Appendix 2 Resource Persons. Input was given during a meeting held with the expert. Prior to the meeting all relevant material was sent to the expert. The meeting was followed up with email, telephone conversation or subsequent meeting where necessary. All experts were given the opportunity to approve or confirm when they were quoted in the report.

Survival data

For estimation of the number of persons dying from a disease, the relative survival is used. The relative survival is the observed survival divided with the expected survival for the background population with the same age and sex distribution (Kræftens Bekæmpelse (2003a)). Therefore, the number of persons dying can be interpreted as the excess mortality which can be attributed to the disease.

Transition probabilities

A transition probability describes the patients move from one disease state to another. The transition probabilities depend, among other things, on the actual treatment given. The transition probabilities are based on Danish data.

In the literature, 5 and 10 year survival probabilities will often be available. However, in order to estimate expected lifetime costs, 1 year transition probabilities are needed. Calculation of transition rates from t year probabilities are based on the exponential distribution as this is a commonly used distribution for this purpose.

Economic data

All cost data reflect 2002 values. When 2002 cost estimates are not available, the most recent cost data are used and inflated to 2002 values. The Danish consumer price index for health care services is used to inflate the costs data.

Patients' co-payments are not included in the direct costs as this part is included in the WTP estimate.

An utilisation rate describes the yearly expected number of services used. The utilisation rates are based on Danish data. When no data are available, the utilisation rate is based on an expert assessment.

Hospital costs are based on the Danish DRG (Diagnosis Related Groups) (2002) system covering all hospital services.

Costs of Primary Health Care Services, are based on the agreed rates for 2002 between 'Sygesikringens forhandlingsudvalg', 'Foreningen af specialpraktiserede læger (FAS)' and 'Praktiserende lægers organisation (PLO)'.[3]

Drug costs at the hospitals are covered through the DRG-system. Data on costs of prescription drugs related to each disease has been estimated either from published data or expert input.

4.3 Individual welfare loss

The individual welfare loss shall express the cost in terms of pain and suffering for the victim following the disease as well as worry and grief caused to close relations.

The individual welfare loss can be said to include following elements:
- Loss of income due to restricted working capacity
- Loss of leisure time
- Loss due to pain and suffering
- Loss due to private medicine and treatment costs
- Suffering and sacrifice for close relations

There are two distinguished approaches for estimation of the welfare loss, namely "the human capital approach" and the "Willingness to pay (WTP) approach". Figure 4-1 gives an overview of which of the above-mentioned cost elements are included in the two methods. The methods are further described below.

Table 4-1: Elements included in human capital and WTP approach

	HC	WTP
Loss of income due to restricted working capacity	X	(X)
Loss of leisure time	(X)	X
Loss due to pain and suffering		X
Loss due to private medicine and treatment costs		X
Suffering and sacrifice for close relations		(X)

4.3.1 Human capital approach

In the human capital approach, humans are viewed as capital like other kind of capital for a production process. In this regard, a human life is valued in

[3] The costs data for Medical Specialists are for 2003 as the rate for these services are adjusted every second year only. Therefore the rates for 2003 were assumed to reflect the values for 2002 also.

terms of what it is worth in terms of input for production, which is equal to the lost future contribution to the production of the society. The human capital approach thus estimates the welfare loss by the gross production loss. Besides the net production loss (described in section 4.4 below) this includes the individual's loss in terms of lost income, corresponding to the first bullet above, whereas the remaining four bullets are not included.

One way of improving the human capital method is to add a statement of the cost in terms of lost leisure time. Such an approach is described further in *Danish Road Directorate* (2002). Inclusion of this element will improve the estimates of the human capital method, but will still lack the remaining three bullets (Loss due to pain and suffering, loss due to private medicine and treatment costs, and suffering and sacrifice for close relations).

4.3.2 Willingness-to-pay approach

The WTP approach on the other hand seeks to estimate the welfare loss by revealing their willingness to pay for avoiding (or accepting) the risk of a certain morbidity impact. The methods for this can be divided into stated preferences and revealed preferences method. In stated preference method the WTP is estimated people are directly asked about their WTP, whereas revealed preferences method seeks to reveal the WTP by looking at the behaviour on related markets.

There are numerous problems related to the performance of a WTP study, and in order to deal with these problems, it tends to be the very resource demanding to carry out a WTP study. This is mainly the reason why very few adequate WTP studies of morbidity issues have been carried out.

Thus, whereas the human capital approach does not include all aspects of the welfare loss, the WTP approach may be critical in terms of its degree of accuracy.

4.3.3 Estimation of WTP by benefit transfer

Due to the complexity of carrying out a WTP study, the most commonly used approach for estimating the individual welfare loss in this regard is use of *benefit transfer*. Benefit transfer is defined as the "use of existing information designed for one specific context to address policy questions in another context" (Pearce, 2000). There are numerous additional problems connected with benefit transfer besides the problems connected with performance of the WTP study itself and, thus, benefit transfer should be used with caution. A number of issues affecting the WTP value must be considered and compared between the original study and the actual case. Especially, following issues are of importance:

- *End points to be valued:* It must be considered how close the end-points valued in the original WTP study are to the end-points to be valued. For example, cough for three days may not be three times the value of cough for one day. Thus near-identical health end point is important

- *Income level:* The income level is likely to be of substantial importance. In connection with benefit transfer, income level as well as income elasticity should be considered

- *Age:* The relation between age and WTP is especially important in relation to death risks. Here it is often suggested that the relationship forms an inverted u-curve. Other studies, however, indicates positive as well as negative relationship between the two. In relation to morbidity effects the picture of the relationship is even more unclear. Due to this, it will be assumed that age does not affect the WTP in the present study.

- *Cultural differences:* It very likely that cultural aspects affect the WTP. However, there is no empirical evidence for this, since it is very different to set up systematic relationship in this connection. It is advised not to perform benefit transfer among population groups containing large cultural differences. A special issue of interest in this connection is possible differences in sickness security systems.

4.3.4 Valuation methodology in the present study

In the present valuation study, the individual welfare loss will be estimated by benefit transfer from WTP studies to ensure that all elements of the welfare loss in principle are included although it is recognized that these estimates are likely to be very uncertain, which will result in high deviation in low and high estimate relative to the mean value.

As mentioned above there are a number of critical issues that must be considered in the design and performance of the WTP survey. This relates to e.g. the formulation of the questions, the method used for collection of answers, the population group asked, their degree of understanding the morbidity effect etc.

In the present study, we do not investigate the original surveys for such critical issues. We will use generally accepted studies by assuming that they are designed and performed in the best possible way. In addition to this, we will consider other person's critical review of these studies and highlight these issues if they are considered important in the present context.

The critical issues related to benefit transfer will be taken into account in following way:

The original values will be adjusted to 2002-prices by the official Danish consumer price index (Statistics Denmark, 2003b). In case of international values, the original WTP estimates will be corrected for differences in per capita income level, where the income level is adjusted for differences in purchasing power by such index values from Eurostat. After this correction, the value is inflated to 2002 prices.[4]

Furthermore, differences in end points valued and cultural differences should be taken into account. It is not so obvious, however, how to correct quantitatively for these factors. In the present context these issues are addressed by introducing high uncertainty intervals on this cost element in connection with development of low and high unit cost estimate (section 10.2.2) in cases of benefit transfer from studies of very different end points

[4] This is the usual way to make this correction, first to make the adjustment from one country (and currency) to the other country using the PPP rates and then do the inflation/deflation adjustment. It implies a small uncertainty - much les than do all other elements of benefit transfer.

and/or studies from a country with large cultural differences compared to Denmark.

4.3.5 The welfare loss and the disease course

How estimation of the welfare loss is connected to the defined course tree depends on, how the WTP is discovered. Either, people may be asked about their willingness to pay for each state in the course tree and these values are subsequently combined with the probabilities of the various states. Or people are asked about their total WTP for avoiding a certain diagnosis/illness. The latter is clearly the simplest one, but it does demand that detailed information about the course of the illness is provided for the respondents in a way that ensures that people asked do fully understand the consequences of the disease.

The approach used here depends on the data available from other studies, which will be used for benefit transfer. Since data within the different diseases differs in shape, the approach differs somehow among the diseases valued. The concrete approach used within each disease is described in the disease specific chapters.

4.3.6 Existing data - morbidity

As mentioned earlier, rather few studies have actually provided estimates of individual welfare loss of diseases by carrying out WTP surveys. We have searched for exiting studies relevant to this project and have found, that exiting estimates steams from very few actual WTP surveys. Below an overview of the estimates that are most frequently used.

Source	State/disease	Estimate, DKK 2002	Comment
Navrud, 1997	Through congestion (per day)	109	
	Eye itching (per day)	133	
	Coughing (per day)	109	
	Headache (per day)	195	
	Sinus congestion (per day)	211	Also used in RPA(2003)
	Acute bronhitis (per day)	227	
	Shortness of breath (per day)	289	
	Asthma attack (non-asthmatics)	625	
	Asthma attack (asthmatics)	1.297	
CSERGE, 1999 (5-country study)	Hospital admission	3.730	
	Emergency room visit	1.926	
	3 days spent in bed with respiratory illness	1.182	used in ExternE, Pearce (2000) and RPA (2003)
	One day with persistent cough	329	
	One day with ichy, watering eyes	427	
	One day of persistent nausea or headache	427	
Aimola, A., 1998	Lung cancer (non-fatal)	401.135	
	Uterine cancer (non-fatal)	722.043	Also used in RPA(2003)
	Prostate cancer (non-fatal)	4.011.349	and in Pearce (2000)
	Leukaemia (non-fatal)	5.856.569	
Murduch et al, 1990	Skin cancers non-fatal)	240.681	Taken from Pearce (2000)
Otterström, 1998	Symptom day	83	
	Asthma attack day	156	
	Restricted activity day	285	Used in ExternE
	Emergency room visit	342	
	Hospital admission	2.155	
	Children's cough day	236	
Extern E	Non-fatal cancer	3.610.214	Estimate not well documented

The estimates used here will be found within this list.

4.3.7 Individual welfare loss in connection with mortality

The value of a statistical life is used with regard to assessing the welfare loss from mortality.[5] There are many complications attached the concept of estimating the welfare loss from increased mortality. Only, two problems related to the application of the value of a statistical life should be mentioned here.

Firstly, it is an ongoing discussion whether to correct for the average age of the patient by using the value of a life year lost (VOLY) or using the age independent value of a statistical life (VSL). The key issue in the discussion is the empirical evidence on whether there is a link between WTP and remaining lifetime. As the current empirical evidence seems not to indicate a proportional relationship, which is required for supporting the use of VOLY, in most cases the VSL is suggested. However, the age aspect is then partly taken into account by modification of the VSL. The specific choice of value is discussed in the next section. Overall, it has been decided to use the value of a statistical life and not the VOLY approach, based on recommendations of DEPA (2003).

[5] In relation to the terminology used in EC study ExternE (Externalities on Energy), this corresponds to 'acute mortality'.

Secondly, it may be stated, that the value will be dependent of the cause of death. E.g. one may point on the "dread effect" of cancer compared to other diseases or accidents[6]. This issue is not further addressed here.

4.3.8 Existing data - mortality

There are numerous sources of a value of a statistical life. For the present purpose, it has been decided to use an estimate that has been used by DEPA in other similar studies. This value is based on the work and recommendations behind developing a set of EU standard values. Through the large study on external costs of energy production, called ExternE, many unit values were developed. In order to prepare a set of standard benefit values to be used in relation to air pollution, the EU Commission called a panel of valuation experts to address the issue of how to value the welfare loss for changed mortality. The recommendation of the panel was used in the development of the benefit tables, named the BeTa database[7].

The standard estimate for value of a statistical life recommenced by the EU panel is € 1.4 million (1999-prices). Furthermore, they propose to use an estimate of € 1 million in connection with air pollution to take into account the fact that it is mainly older people that die from air pollution. This means that the estimate of € 1 million includes the age aspect[8].

A choice had to be made whether to use the standard value or the one including the age aspect. Since the estimate in the present study is to be used in connection with lung cancer, which mainly hits people above a certain age, it may seem appropriate to use the estimate corrected for the age aspect. Furthermore, this estimate has been used as basis in other valuation studies of DEPA, and thus ensures consistency between different works of DEPA it is preferable to use the same value.

It has then been decided to use the estimate of a VSL generally recommended by DEPA, which is based on the age corrected value suggested by the EU Commission. In this way we ensure consistency with other DEPA studies. Also, the age aspect is taken into consideration in the cases when is most needed without making specific age corrections[9].

DEPA recommends a value of DKK 9.64 million, (2002-prices), which arises from the value of the EU Commission of € 1 million, corrected for differences in purchasing power and then inflated to 2002 price level. For further information, see DEPA (2003).

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[6] In a number of analyses by the European Commission, a risk premium of 50% is utilised for fatal cases, see for example: http://europa.eu.int/comm/environment/enveco/air/pah_report.pdf

[7] Central parts of data foundation and documentation is found in BeTa - Benefits Table database: http://europa.eu.int/comm/environment/enveco/studies2.htm#Marginal%20external%20costs%20air%20pollution

[8] See the BeTa - Benefits Table database documentation.

[9] For chronic or deadly diseases assumptions about average age at the occurrence of the disease have been made. This is necessary for being able to estimate the total cost of the disease.

4.4 Production loss

This component refers to the loss of the society from less production due to morbidity or mortality. It should be emphasised that the production loss here is something else than individual welfare loss measured through the human capital approach. Here, production loss refers to the issue of whether there is reduction in the aggregated national product that is not accounted for in the individual welfare assessment. Such a production loss is independent of the approach used to assess the individual welfare loss. See section 4.4.1 below for further description.

Illness means that the work ability decreases. This results in a loss to the society corresponding to the value of the additional output that could have been produced in the absence of illness.

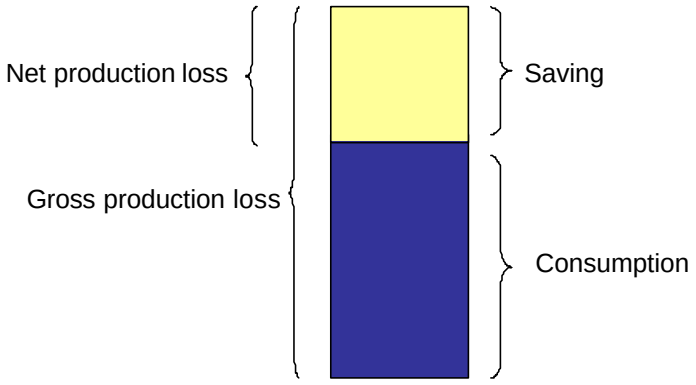
It is necessary to distinguish between gross and net production loss. Gross production loss refers to the value of the additional output that the individual could have produced if the disease had not incurred. The net production loss deducts the consumption from the gross production loss, which corresponds to the net savings.

Whether to include the gross or net production loss in the unit cost estimation depends on what is included in the other cost components (especially in the welfare loss estimate). In the present study, the approach is to include the gross production loss under illness. The reason for this is, that it is generally expected, that people to a high degree are compensated economically during the illnesses considered here, and therefore do not include production loss in their WTP. The production loss is still present however; it is just paid by either the government or private insurance companies. Section 4.4.1 below explains in further details why this seems to be the most appropriate approach in the present context.

4.4.1 Links to other cost components

The gross production loss can be divided into two parts: (1) the part accruing to the individual in terms of lost consumption possibilities and (2) the remaining part (called the net production loss) corresponding to loss of net saving to the economy. The loss for the society due to lost working ability corresponds to the gross production loss.

Figure 4-3: Illustration of gross and net production loss



The part of the production loss reflecting loss of consumption possibilities will normally be included in the WTP estimate of the individual welfare loss, and thus should in principle not be included in the production loss estimate as well.

In case of disease, people are normally compensated financially to a certain degree by the social benefits or by a health insurance. The degree of compensation differs from case to case and also among countries. If the individual is fully compensated during illness, in principle, the WTP estimate does not include part of the gross production loss. In this case, the gross production loss should be added to the WTP estimate in order to provide an estimate of the total indirect costs. If on the other hand the individual is not compensated at all, the lost consumption possibilities is expected to be included in the WTP estimate and following this the total indirect should be estimated as the WTP estimate plus the net production loss.

Thus, it depends on whether loss of consumption possibilities is included in the WTP estimate or not. It is rather normal that the employed are fully compensated, meaning that salary is paid during illness, up to a certain number of sick days. After this limit the person is partially compensated by sickness benefit from the state and/or insurance. In a longer time perspective the person may loose his job and receive social security benefit or national supplementary disability pension. Thus, the person affected by sickness will normally be financially compensated to a high extent. Following this, the person will only to a limited extent experience an income decrease and therefore it is likely that the individual welfare loss estimated by WTP for avoiding the disease does not include loss of consumption possibilities.

There may be differences among countries regarding the degree of compensation during illness, which is of importance in connection with benefit transfer from WTP studies from other countries. And to the extent that degree of compensation is substantially lower in countries from which benefit transfer is carried out compared to Denmark, this may result in an overestimation of the indirect costs. This aspect, however, has only a limited impact on the estimates of the direct costs in the present study and is therefore not considered further in the present analysis.

To sum up, the production loss to be included is the gross production loss, unless it is expected that loss of consumption possibilities are somehow included in the WTP estimate.

To avoid double counting this means that public expenditure for sickness benefit etc. is not included. It should be kept in mind, that this approach does not necessarily give an appropriate picture of the distribution of the expenditure burden.

In the case of death, it is normally recommended to use the net production loss along with a WTP based statement of the individual welfare loss, since the loss of consumption possibilities will be part of the estimated value of WTP for avoiding a certain death risk. It is also in most cases assumed that the respondents in WTP surveys do not include more general losses to the society. Therefore, the net production loss should be included. It is an issue that not always have been proporly addressed in the various studies on values

of a statistical life. However, to give a comprehensive assessment, it should be included.[10]

4.4.2 Production loss and age dependency

Like for the individual welfare loss it is an ongoing discussion whether the value of the production loss should vary with the age of the individual. The argument for such a variation is that more production is lost when the person is in the highly productive age compared to a person being at a less productive stage of its life (very young or rather old). The implication of using different values according to the age is that the health of a rather productive person will be preferred from an economic point of view over the health of an old (or a very young) person all other things being equal. Same argument could be given then in relation to men and women. Since primary income is lower for women than for men, initiatives supporting men's health should be preferred over initiatives supporting women's health, all other things being equal. This may be problematic since not-market production value such as work in the household is not included in the income values.

Ethically, this may be considered as problematic, and it sometimes recommended not using such an approach. A rational argument against production loss values varying with the age is that the individual contribute to the society with his production and tax payments under the assumption that he will benefit from this not only today but also when he gets old.

In the present study an average value for the production loss not related to the age of the patient will be applied, meaning that production loss contain same value no matter the age of the individual.

It should be added that the production loss will be estimated for each year of the disease or each year of the remaining life time, if a chronic disease, or for each year lost in case of death. In these cases, the accumulated value of the production loss naturally will be higher the younger a person.

4.4.3 Gross production loss estimation in the present study

The estimation of the gross production loss will be based on the approach used in "Revision af uheldsomkostninger 1998", made by COWI for the Danish Road Directorate.

Here, the production loss is estimated from the "primary income". The Primary income is defined as income in terms of salary and surplus from independent business. It is distinguished from the term personal income by not including transfer income, which is not a product of business activity.

The primary income is expressed as an average over the total population. Thus, the primary income concept is a measure of the average earnings taking into account the occupation frequency.

[10] In Cost 313 (1994) there is a broad discussion on valuation methodologies concluding (page 69) that WTP estimates should be complemented with net production losses, unless this element specifically has been included by the respondents in their WTP values.

In the present study it has been decided not to apply different production loss values for different age groups neither for men or women (see discussion in section 4.4.2 above). Consequently, the average production loss has been estimated, based on Statistics Denmark (2003b)

The primary income reflects the yearly income. The consequences on working ability from various diseases will in many cases be expressed in terms of lost working days. Thus, the primary income figures should be expressed per working days as well. 2001 included 252 working days. This results in an average production loss of DKK 533 per working day lost. The key figures of the estimation are seen in Table 4-2 below.

Table 4-2: Estimation of average production loss per day, 2001 values

Average primary income	Number of working days	Production loss per day
DKK 134,292	252	DKK 533

4.4.4 The net production loss in the present study

The net production loss will be used in connection with valuation of a certain death risk. The value should be based on the net saving rate of the society. Since it is likely to vary from year to year, the net saving rate is estimated as an average over three years (1999-2001). Based on figures from the National Account (Statistics Denmark, 2003b), the average net saving rate is 10.4%. This results in an estimate of the net production per lost working day, corresponding to 10.4 of the primary income, that is DKK 55 per day.

With an assumption of 252 working days per year in average, the net production loss in case of death will be DKK 13,937 per year.

5 Asthma bronchiale

The symptoms of asthma bronchiale are repeating attacks of difficulty in breathing, coughing with phlegm or hissing breathing.

The reaction can be reduced by avoiding certain substances and by taking in preventive medicine. By serious attacks the patient must seek help by the doctor or emergency room.

5.1 Definition

Asthma bronchiale is a pulmonary disease characterized by reversible airway obstruction, airway inflammation, and increased airway responsiveness to a variety of stimuli. Asthma bronchiale is classified as J45 (Asthma bronchiale) in the ICD-10 classification of diseases.

Starting age for the disease is assumed to be at the age of 40.

5.2 Chemicals associated with Asthma bronchiale

For asthma it is relevant to distinguish between the disease asthma and an asthmatic episode. It is very rare that chemicals will cause the disease asthma. Mosbech assesses that this is the case in less than 1 % of the incidences (Mosbech (2003)). Instead, chemicals are more likely to be irritants causing an asthmatic attack for people with asthma.

5.3 Disease course

Two different disease courses are relevant for chemicals related to asthma patients.

1. Chemicals causing an asthmatic episode

   Chemicals may cause an asthmatic attack for a person with asthma. In this case, only the asthmatic attack can be attributed to the chemical. The process of establishing a diagnosis, managing the patient's every day treatment are not related to chemical per see.

2. Chemicals causing the disease asthma

   As mentioned, in rare cases chemicals can cause the disease asthma. In this case, diagnosis, long term treatment and asthmatic episode can be attributed to chemicals.

As indicated, the former is the most relevant in relation to chemicals. In order to address, however, the need for various applications of the cost estimates, costs will be estimated for the following components:

- Cost per asthmatic episode

- Lifetime costs of asthma with 3 yearly asthmatic episodes (including cost of diagnosis, long term treatment and asthmatic episodes)

In general, asthma treatment can be grouped in to the following categories[11]:

- Diagnosis
- Long term management
- Acute care

Diagnosis relates to the process of diagnosing the patient, long term management is the daily treatment for managing the disease, and acute care is treatment related to an asthmatic episode.

An asthmatic episode is defined as an asthmatic episode which acquires treatment not included in the long term management; i.e. additional medication, emergency room visit, hospitalisation, etc (Mosbech (2003)).

The average person with asthma will have 3 asthmatic episodes per year (Mosbech (2003)). In relation to chemicals, it is difficult to assess the number of asthmatic episodes. When the chemicals causing asthmatic episodes are removed, the person will no longer experience asthmatic episodes. Therefore, it is not possible to estimate or asses the average number of chemical induced episodes a person will experience every year. This will depend on the intensity and number of exposures during the year.

5.4 Direct costs

Cost per asthmatic episode

When a patient has an asthmatic episode, the patient will take medication to relief the symptoms and in some cases seek medical assistance. With respect to medication, the patient will typically take 1 DDD (Defined Daily Dose) of Selective beta-2-adrenceptor agonists (ATC-group R03AC) to treat the acute episode (Mosbech (2003)). In addition to this, the patient will for two weeks take double dose (2 DDD per day) of the medication used for daily treatment. Therefore, 1 DDD per day for two weeks can be attributed to the asthmatic attack. In the calculations, the costs of medication are made separately for the two kinds of medicine (Lægemiddelstyrelsen (2001);(2003)). Costs of hospitals services are based on the average use of hospital services for asthmatic patients (moderate to severe patients) within one year (Søndergaard et al. (2000)). Costs of use of GP (General Practitioner) services were not included. The use of these services could not be attributed to the asthmatic episodes per see as they were assessed to reflect routine visits only.

[11] The probability of dying from asthma is very low and is omitted in the following calculations According to EPA in the US, the annual probability of dying from asthma is 0,0004 (EPA (2000)).

Table 5-1 Direct costs per asthmatic episode (DKK in 2002 values)

Service	Number	Costs	Total costs in DKK 2002 values	Sources
Hospital services				
Hospitalisation	0.06	12,194	706	(4;6)
Ambulatory visit	0.16	1,339	218	(4;7)
Emergency room visit	0.02	799	17	(4;7)
Total costs per year			941	
Numer of asthamtic episodes per year	3.00			(31)
Costs of hospital services			314	
Medication				
DDD per asthmatic episode	1.00	6	6	(19;31)
Increased medication in DDD for two weeks	14.00	7	97	(19;31)
Total costs of medication			103	
Total direct costs			417	

Costs of medication are public expenditures only
DDD Defined Daily Dose
Sources: The first number refers to source for the number of services. The second number refers to source for the costs per service.
See appendix 1 with list of sources for the calculations.

The total direct costs of an asthmatic episode are estimated to be DKK 417 (Table 5-1). Approximately 75% of these costs reflect use of hospital services.

Cost of diagnosis

The GP refer patients to either Medical Specialist or Hospital Ambulatory. The Medical Specialist seldom refers does not refer patients to Hospital Ambulatory for diagnosis (Mosbech (2003)).

Table 5-2 Costs of diagnosis for asthma patients (DKK 2002 values)

Service	Number	Costs	Total costs	Sources
Diagnosis at GP				
GP Consultation	3	105	315	(1;9)
Total costs			315	
Percentage diagnosed at GP	20%			1
Expected costs of diagnosis at GP			63	
Diagnosis at Medical specialist				
GP Consultation	2.5	105	263	(1;9)
1st consultation MS	1	502	502	(1;13)
2nd consultation MS	1	276	276	(1;13)
Subsequent consultations MS	0.5	135	67	(1;13)
Cutan test	8	13	102	(1;13)
Blood test	1	11	11	(1;13)
Total costs			1,221	
Percentage diagnosed at Medical Specialist	10%			1
Expected costs of diagnosis at Medical Specialist			122	
Diagnosis at Hospital Ambulatory				
GP Consultation	2.5	105	263	1
Ambulatory visit	3	1,339	4,017	1
Total costs			4,280	
Percentage diagnosed at Ambulatory	70%			1
Expected costs of diagnosis at ambulatory			2,996	
Direct total costs			3,181	

GP General Practitioner

Sources: The first number refers to source for the number of services. The second number refers to source for the costs per service.
See appendix 1 with list of sources for the calculations.

70% of the patients are diagnosed at the Hospital ambulatory. For a patient being diagnosed at the Hospital ambulatory, total costs are DKK 4,280. Since this is the case for 70% of the patients, expected costs are DKK 2,996. When including costs of GP and Medical specialist, direct total costs of establishing the diagnosis are DKK 3,181.

Costs of daily treatment

Costs of daily treatment reflect the average use of services within a year. This includes services related to asthmatic episodes, preventive medication and routine visits to GP.

Table 5-3 Yearly costs of treatment for asthmatic patient (DKK 2002 values)

Service	Number per year	Costs	Total costs	Sources
GP				
GP Consultation	1.04	105	109	(4;9)
Out of hours visits (average costs)	0.16	270	44	(4;9)
GP Telephone consultation	1.64	25	41	(4;9)
Medical Specialist				
1st consultation MS	0.07	502	37	(4;13)
Hospital services				
Hospitalisation	0.06	12,194	706	(4;6)
Ambulatory visit	0.16	1,339	218	(4;7)
Emergency room visit	0.02	799	17	(4;7)
Medication				
Medication	1.00	2,988	2,988	4
Total direct costs			4,160	

Costs of medication are public expenditures only

GP General Practitioner

Sources: The first number refers to source for the number of services. The second number refers to source for the costs per service.
See appendix 1 with list of sources for the calculations.

Total direct costs are DKK 4,160 for one year (Table 5-3). As seen from the calculation, the most important component is costs of medication with DKK 2,988 per year.

5.5 Individual welfare loss

The welfare loss value is based on Navrud (1997/2000). In his survey the respondents were asked about their WTP for avoiding an additional day of asthma attack.

The objective of Navrud (1997/2000) was to valuate the individual WTP to avoid seven light health symptoms and asthma. The method was a contingent valuation (CV) study, where 1,009 Norwegians were asked about their preferences. First, people were asked to evaluate their overall health state, and whether they could do anything to influence their own health. Then they were asked how many days they experienced having each of these seven "light" symptoms and asthma the last 12 months, how it had restricted their activities, and their private costs of having these symptoms. Next, they were presented by cards describing the symptoms and were asked to rank them.

The respondents were divided into two subsamples. One was asked about the WTP to avoid one additional day having the symptoms within the next 12 months, whereas the other subsample was asked about the WTP to avoid 14 days having the symptoms.

As expected, the results showed declining marginal value of a symptom day comparing the two subsamples. The average WTP per symptom day from subsample B (14 additional symptom days) was 18-32% of the value of a marginal symptom day found in subsample A.

Mean values are in general higher than the corresponding median values due to the high variance in the WTP of the people asked. Whereas the median values probably accord better with most people's introspection, the mean value takes into account the people that have much higher WTP than most

people e.g. because they cannot take the medicine needed etc. For the present purpose the mean values are used.

For asthma, the answers were divided on people with asthma and people not having asthma. Persons with asthma were willing to pay DKK 1,297 (2002-prices) whereas person without asthma were willing to pay app. the half, DKK 625. For further description of the survey we refer to Navrud (1997/2000).

The estimates were discussed with an expert of asthma (Dr. Med. Holger Mosbech), who found the estimates as well as the differences between the answers of the two categories of respondents appropriate. The reason for the relative high WTP of asthmatics compared to non-asthmatics may be that asthmatic people know about the actual inconvenience and especially the fear of death that often appear in connection with a serious asthma attack (even though very few patients die from an attack).

Otterström et al. (1998) estimated the WTP of avoiding a day of asthma attack to only DKK 156 per day, which seems rather low according to the expert statement of the present study.

Since chemical induced asthma attacks normally occur for asthmatic people only seems most reasonable to use the WTP from asthmatic people in the present context. Corrected for income and purchasing power, the WTP estimate used in the present context is *DKK 1,186*.

5.6 Production loss

In Søndergaard et al. (2000) it is estimated that the average number of days absent from work due to asthma is 2.2 days per year. Based on expert judgement it is assumed that the number of attacks per year is 3 in average. This results in 0.73 days absent from work per asthma attack. Consequently, the production loss per asthma attack will be DKK 391.

This approximately means that each attack results in a day of sickness. The reason of using 0.73 day per attack and not 1 day per attack is due to the fact that some attacks will arise during non-working days.

5.7 Unit cost estimate

5.7.1 Costs per asthmatic episode

The total unit cost of an asthmatic episode is DKK 1,933. The direct costs are DKK 417 and indirect costs are DKK 1,576. Thus, the indirect costs are responsible for 79% to the total unit costs.

Table 5-4 Total costs per asthmatic episode (DKK 2002 values)

Cost component	Costs	
Direct costs		
Acute episode	417	21%
Total direct costs	417	21%
Indirect costs		
Production loss	391	20%
Welfare loss	1,186	59%
Total indirect costs	1,576	79%
Total costs	1,993	100%

5.7.2 Lifetime costs

In order to illustrate potential costs over a number of years, lifetime costs for a person who acquire chemical induced asthma are estimated (Table 5-5). The example is made for a at 40 years old person acquiring asthma and assuming 3 asthmatic episodes per year.

Table 5-5 Lifetime costs of asthma (DKK 2002 values)

Cost component	Discount rate 0%		**Discount rate 3%**		Discount rate 6%	
Direct costs						
Daily treatment	158,097	48%	**96,386**	48%	65,472	47%
Diagnosis	3,181	1%	**3,181**	2%	3,181	2%
Total direct costs	161,278	49%	**99,567**	49%	68,653	50%
Indirect costs						
Production loss	32,671	10%	**19,918**	10%	13,530	10%
Welfare loss	135,158	41%	**82,401**	41%	55,972	41%
Total indirect costs	167,828	51%	**102,319**	51%	69,502	50%
Total costs	329,106	100%	**201,886**	100%	138,155	100%

Age of onset is 40
Expected remaining lifetime is 38 years (Statistics Denmark (2003a))

Total lifetime costs of asthma are DKK 201,886 (3% discount rate). Direct and indirect costs are responsible for approximately half of the total costs respectively.

6 Headache

Headache is a common symptom, often associated with disability, but rarely life threatening.

When a new headache occurs for the first time in close temporal relation to chemical exposure, it is coded as (secondary) headache attributed to the chemical (The International Classification of Headache Disorders (ICHD-II) (2003)).

Headache may be acute or chronic. When exposure to a substance ceases but headache does not resolve or markedly improve after 3 months, a diagnosis of chronic post-substance exposure headache is considered. However, such headaches have not been documented in relation to chemicals and is therefore only for research purposes (ICHD-II (2003)). Hence, the headache considered in this section is acute headache induced by acute substance use or exposure.

6.1 Definition

The headache analysed in this section is defined as headache induced by acute substance use or exposure. This diagnosis is classified as 8.1 in ICHD-II (2003).

For the present purpose, each episode is defined as " Two painful and splitting headaches during the day. Each period of headache will last two hours" (Navrud (1997). Operationalisation of this definition is made in Table 6-1 below.

Table 6-1 Definition and operationalisation of acute headahce

Definition of acute headache	Operationalisation	
Two painful and splitting headaches during the day*	Direct costs	Indirect costs
	2 DDD of mild analgesics	50% production in work ability

* Navrud (1997)
DDD Defined Daily Dose
Mild analgesics is, e.g. paracetamol

In is assumed that the patient is taking 2 DDD of analgesics and has 50% reduction in work ability during one episode of headache.

6.2 Chemicals associated with Headache

The following categories of chemicals are often mentioned to cause headache[12]:

- Organic solvents

[12] EPA US Enviromental Agency (1995).http://immuneweb.org/articles/fabricsoftener.html

- Chemical irritants

Other type of chemicals may also cause headache depending on the intensity and length of time of exposure.

6.3 Disease course

The patient may experience one or more episodes. It is not likely that the patient will seek medical assistance when having a few acute episodes of headache (Olesen, J. (2003)). In this situation, the patient may take analgesics to relief the headache. However, with multiple episodes of acute headache, it is likely that the patient will seek medical assistance and have a proper diagnosis established.

In order to illustrate the costs in the two situations, the following cost estimates are provided:

- Costs per acute episode of headache
- Costs for 10 acute headache episodes including costs of diagnosis

6.4 Direct health care costs

Costs of an acute episode

Direct costs of an acute episode of headache consist of drug costs only. It is assumed that the patient will take 2 DDD of mild analgesics, e.g. (paracetamol) in relation to an acute episode. The costs are estimated to be DKK 1.30 (2*0.65 =1.30). The costs of 10 acute episodes are calculated strait forward as 10*1.30 = DKK 13.

Table 6-2 Direct costs per acute episode of headache (DKK 2002 values)

Number of episodes	Medication	DDD per episode	Costs/DDD	Total costs	Sources
1	Mild analgesics	2	0.65	1.30	(14;20)
10	Mild analgesics	2	0.65	12.98	(14;20)

Costs are public costs only as the patient's co-payment is included in the indirect costs
Mild analgesics has the ATC code N02B
Costs/DDD is average costs per DDD within ATC group N02B
ATC is Anatomic Therapeutic Group
Sources The first number refers to source for the number of DDD.
The second number refers to source for the costs per DDD.
See appendix 1 with list of sources for the calculations.

Cost of establishing the diagnosis

In Table 6-3 an overview of health care resources in relation to establishing a diagnosis is given. Most of these patients will be treated by the general practitioner (GP), and only very few patients will be further referred to Medical Specialist and Hospital Ambulatory. The distribution of patients among GP, Medical Specialist and Hospital Ambulatory is based on expert assessment by Jes Olesen (Olesen, J. (2003)).

90% of the patients will have 2 consultations at the GP only. The costs of two consultations at the GP are DKK 210. As 90% of the patients are treated at

the GP only, the expected costs for the average patients are DKK 189 (0.9 *210 =189).

The 10% of the patients being referred to the Medical Specialist has had 3 consultations at the GP before referral. At the Medical Specialist they will have 3 consultations. 33% will have a CT scanning and 10% will have a MR scanning. Total costs for patients diagnosed at the Medical Specialist are DKK 1735. As this is only 10% of the patients, the expected average costs are DKK 173.

1% of the patients will be further treated at the Hospital Ambulatory. Total costs for these patients are DKK 10.275 resulting in expected average costs of DKK 103.

Total expected costs of establishing the diagnosis are therefore DKK 465 when expected costs for each category are added together.

Table 6-3 Costs of establishing diagnosis for severe headache (DKK 2002 values)

Service	Number	Costs per service	Total costs	Sources
Diagnosis at GP				
GP Consultations	2	105	210	(14;9)
Total costs			210	
Pct. of patients at GP	90%			14
Expected costs			189	
Diagnosis at Medical Specialist				
GP Consultations	3	105	315	(14;9)
1st consultation MS	1	502	502	(14;9)
2nd consultation MS	1	276	276	(14;9)
Subsequent consultations MS	1	135	135	(14;9)
CT scanning	33%	1058	349	(14;7)
MR scanning	10%	1575	158	(14;7)
Total costs			1735	
Pct. of patients at MS	10%			14
Expected costs			173	
Diagnosis at Hospital Ambulatory				
Medical Specialist			1735	14
Ambulatory visit	6	1339	8034	(14;7)
CT scanning	33%	1058	349	(14;7)
MR scanning	10%	1575	158	(14;7)
Total costs			10275	
Pct. of patients at HA	1%			14
Expected costs			103	
Direct total costs			465	

Expected costs	Total costs multiplied by the percentage of patients receiving the service
Sources	The first number refers to source for the number of services. The second number refers to source for the costs per service. See appendix 1 with list of sources for the calculations.
GP	General Practitioner
MS	Medical Specialist
HA	Hospital Ambulatory

6.5 Individual welfare Loss

The Definition of a day with moderate headache used in the present study is taken from the valuation study reported in Navrud (1997/2000), which will be used in the present context to estimate the welfare loss by benefit transfer. The CV survey is described in chapter 5.5 of the present report.

The value per day of headache when 14 days are considered is about one third of the value on one day of headache. In the present study the value on one additional day is used, due to the present definition of an episode.

The estimated value of avoiding an additional symptom day is DKK 195 (2002-prices). Purchasing power corrected per capita income level in 1997 was 9.4% higher in Norway that Denmark, resulting in a corrected estimate of *DKK 179 per day*.

6.6 Production loss

It has not been possible to get accurate data on the extent of absence from work due to moderate headache. For the present purpose it is assumed that a moderate headache in average leads to a degree of absence from work of 35%. This corresponds to a 50% reduction in the individuals work ability during an episode of moderate headache taken into account that appr. 70% of the episodes will appear on non-working days. This results in an average production loss of *DKK 184 per episode.*

6.7 Unit cost estimate

The total unit cost has been estimated for an episode of acute headache supplemented by an example of a scenario of 10 repeating headaches, including diagnosis settlement. The result is seen in Table 6-4 below.

Table 6-4 Total unit cost of one and 10 episodes of acute headache (DKK 2002 values)

Component	Costs of one episode	%	Costs of 10 episodes and diagnosis	%
Acute episode	1,30	0%	13	0%
Diagnosis	0	0%	465	11%
Total direct costs	1,30	0%	478	12%
Production loss	184	51%	1.840	45%
Welfare loss	179	49%	1.786	44%
Total indirect costs	363	100%	3.625	88%
Total costs	364	100%	4.103	100%

All episodes and diagnosis are within one year

The total unit cost of one episode is estimated to DKK 364. It is apparent that the indirect costs are the most important component is the total costs of headache. For costs of one episode, the direct costs amounts less than 0.4% of the total costs. The production loss is the most important cost element contributing with app. 51% of the total costs followed by the welfare loss amounting 49%.

Estimated cost of the defined scenario of 10 episodes including diagnosis is DKK 4,103. The direct costs now amount app. 11% of the costs, whereas the individual welfare loss and the production loss contribute with 44% and 45% respectively.

In relation to the welfare loss in the scenario calculation one issue should be noted. As the WTP survey (Navrud, 1997) showed, the average WTP per headache day seems to be dependent on the total duration. Likewise, it is likely that the WTP per episode changes with the total number of episodes experienced within a certain period. The WTP survey pointed in the direction of decreasing WTP along with the increase of days of duration, which may also be the case for the defined scenario. On the other hand, since the cause in defined scenario is assumed to result in a need of diagnosis settlement it may give rise to increase worries and this increase the individual WTP. Following this, the WTP for one episode of headache during one day is used in the scenario estimation as well.

7 Contact Allergy

Contact allergy is caused by small chemicals that penetrate the skin. By doing this the chemicals can induce allergy. The process of inducing allergy is called sensitisation and is without clinical symptoms. Once a person has become sensitized re-exposure to the allergen can cause allergic eczema. Allergic eczema is characterised by erythema, oedema, and the skin can become dry, shift and fissures develops.

7.1 Definition

Contact allergy is defined as acute or chronic inflammation produced by substances contacting the skin and causing allergic reactions.

The contact allergy analysed in this section is classified as L23 (Dermatitis contactus allergica) in the ICD-10 classification of diseases.

Starting age for contact allergy is assumed to be at the age of 40.

7.2 Chemicals associated with contact allergy

Contact allergy from chemicals may arise in connection with private use as well as part of the working environment. Product groups containing chemicals with risk of contact allergy are:

- Metals
- Perfumes
- Preservatives
- Dyes
- Rubber

The most frequent cause of contact allergy is the metal - nickel. Second to this, perfumes and preservatives.

It is not possible to be cured from contact allergy. However, it is possible to some extent to remove the allergen. By doing this, the patient can be cured from having allergic reacting. However, the patient will have recurrence of the symptoms when exposed to the allergen again.

7.3 Disease course

The disease course is divided into the following disease states: Diagnosis, Daily treatment and Acute care. The purpose is to have well defined disease states where cost of treatment can be estimated within each disease state.

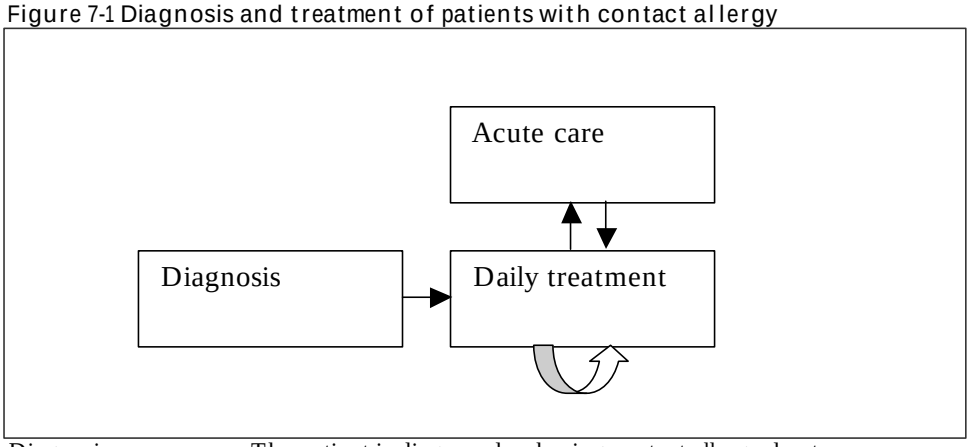
Diagnosis is the state where the patient is having allergic reactions and the diagnosis is in the process of being settled.

Daily treatment with contact allergy is the every day coping with contact allergy. This may include daily treatment with topical agents, moistures and avoidance of certain chemicals. This treatment is opposed to Acute care.

Acute care is when the patient is having an allergic reaction which requires specific treatment that is not included in the long term management of the disease; i.e. additional treatment due to an acute allergic reaction.

Once the patient is allergic toward one substance, it increases the likelihood of becoming allergic towards other substances.

Figure 7-1 Diagnosis and treatment of patients with contact allergy



Diagnosis	The patient is diagnosed as having contact allergy due to chemicals
Daily treatment	Coping in every day life with contact allergy; e.g. avoidance of certain chemicals and daily treatment
Acute episode	Acute attack of contact allergy

Once a person has acquired contact allergy, the person will have it for the rest of the life (Duus and Menné (2003)).

It is known that one type of contact allergy increases the likelihood of becoming allergic towards other substances (Duus and Menné (2003)). This is taken into account as costs of multi-allergy are included in the average cost estimates.

7.4 Direct health care costs

Direct health care costs are estimated for establishing the diagnosis and daily living with contact allergy. Costs of acute care are included in the costs of daily treatment as separate data for acute care and daily living are not available.

Diagnosis

Diagnosis includes all activities related to diagnosing the patient. This is done at the GP, Medical Specialist or at hospital ambulatory. Direct total costs of establishing the diagnosis are estimated to be DKK 1,113 (Table 7-1).

Table 7-1 Direct total cost of establishing diagnosis for a patient with contact allergy (DKK 2002 values)

Service	Number	Costs	Total costs	Sources
Diagnosis at GP				
GP Consultations	2	105.06	210	(25;9)
Allergy test	1	177.06	177	(25;9)
Total costs			387	
Percentage of patients at GP	70%			(25)
Expected costs of diagnosis at GP			271	
Diagnosis at Medical Specialist (Dermatologist)				
1st consultation MS	1	502.11	502	(25;13)
2nd consultation MS	1	276.14	276	(25;13)
Subsequent consultations MS	2	134.53	269	(25;13)
Other services	1	71.00	71	(26)
Total costs			1,118	
Percentage diagnosed at Medical Specialist	29%			(25)
Expected costs of diagnosis at Medical Specialist			324	
Diagnosis at Hospital Ambulatory				
Ambulatory visit	3	1,339.00	4,017	(25;7)
Other services	1	300.00	300	(26)
Total costs			4,317	
Percentage of patients at hospital ambulatory	12%			(25)
Expected costs of Hospital Ambulatory			518	
Direct total costs			1,113	

GP General Practitioner

Sources The first number refers to source for the number of services. The second number refers to source for the costs per service. See appendix 1 with list of sources for the calculations.

Daily treatment for contact allergy

Daily treatment for contact allergy includes all activities related to managing the disease when the diagnosis is settled. This is the daily routine treatment of the disease. This include medication, routine visits to GP, Medical specialists, Ambulatory services, Hospital services, etc. Treatment related to acute care is included in this category also. Estimated yearly costs of treatment are DKK 1,659 (Table 7-2). The major contributors to these costs are hospitals services and medication.

Table 7-2 Direct total cost of yearly treatment for a patient with contact allergy (DKK 2002 values)

Service	Number	Costs	Total costs	Sources
GP services				
GP Consultations	2	105.06	210	(25;9)
Total costs			210	
Percentage of patients at GP	70%			(25)
Expected GP costs			147	
Medical specialist Services (Dermatologist)				
1st consultation MS	1	502.11	502	(25;13)
2nd consultation MS	1	276.14	276	(25;13)
Subsequent consultations MS	2	134.53	269	(25;13)
Total costs			1,047	
Percentage of patients at MS	10%			(26)
Expected Medical Specialist costs			105	
Hospital Ambulatory services				
Ambulatory visit	2	1,339.00	2,678	(26;7)
Total costs			2,678	
Percentage of patients at Hospital ambulatory	0.03			(26)
Expected costs of Hospital Ambulatory			74	
Inpatient Hospital Services				
Average costs per discharge	1	23,500.00	23,500	(36)
Total costs			23,500	
Percentage of patients	0.03			(26)
Expected costs of Hospital Services			653	
Medication				
Topical steorids	1	250.00	250	(28)
Percentage of patients using topical steorids	69%			(27)
Total costs of topical steorids			172	
Total costs of medication etc.			680	
Direct total costs			1,659	

GP: General Practitioner

Sources: The first number refers to source for the number of services. The second number refers to source for the costs per service. See appendix 1 with list of sources for the calculations.

7.5 Individual welfare loss

Estimates of WTP for avoiding contact allergy have not been found. In RPA(2003) an estimate of one additional day with skin disease is provided. This is based on the lowest value of the estimates in Navrud (1997), which is DKK 109, without any clear reason for this.

As an alternative, it has been chosen to estimate the WTP from estimations of WTP of a "symptom day", defined as "one day with mildly, red watering, itchy eyes and runny nose". The value is from a very extensive European morbidity valuation study. The study is often referred to as the 5-country study (CSERGE et. al., 1999 referred in Rainer and Bickel, 2001) and has been the basis for a number of values in Extern E and BeTa.

The survey CV study valuing 6 morbidity episodes in the Netherlands, Norway, Portugal, Spain and the UK and arrogated to values for a pool of the 5 countries. The morbidity episodes were all related to air pollution, but the survey was carried out in a context free mode, i.e. by seeking WTP for changes in given health effects only. The basic idea is that context free WTP provides a core value that might be transferred to other areas.

In the survey, a "symptom day" is about 83 DKK in 2002-prices. Corrected for income and purchasing power differences this corresponds to DKK 100. Even though it is problematic to use this estimate in the present context it is found to be the best possibility available at this stage.

The number of symptom days varies greatly from patient to patient. Here, it is assumed that symptoms will be present approximately 20% of the time, resulting in an estimate of DKK 7,315 per year. It is implicitly assumed that the WTP per symptom day is constant independent of the number of symptom days. There is no basis for determine how the value will depend on the number of days. There could for example be threshold limits partly or fully offsetting the effect of the "standard" assumption of declining marginal WTP values.

It can be discussed whether the private medical expenditures should be added or not. Since the WTP estimate is taken from another context, the medical expenditures connected with contact allergy will not be present in this estimate. On the other hand, the estimate may include private expenditures for other kinds of medicine. Since medical expenses of a symptom day as defined in the original WTP study are likely to be rather limited, it seems most reasonable to add private medical expenses to the WTP estimate.

Based on information from Department of Dermatology in Denmark, it is estimated that each patient in average has additional expenses on lotion corresponding to DKK 200 per month. Furthermore, topical steroids may be used. The average private expenses in this relation is estimated to app. DKK 250 per year In addition to this, some patients may have expenses for special gloves, but this is left out in the present study. In total, this results in private expenses of DKK 2,650 per year

In total, the individual welfare loss amounts DKK 9,965 per year.

7.6 Production loss

In Flyvholm and Burr (2001) the absence from work due to contact allergy is estimated to 1.6 day per year in average. According to Department of Dermatology, Gentofte University Hospital in Denmark it is likely to be to low, but in absence of better documented data, it was recommend using this estimate.

1.6 days per year results in a production loss value of DKK 853 per year.

7.7 Unit cost estimate

The total results of the unit cost estimation are seen in Table 7-3 below. At a discount rate of 3% the total lifetime cost is DKK 291,288 per patient. The main cost element is the welfare loss, counting for 79% of the value.

Table 7-3 Unit cost estimate for contact allergy, lifetime cost per patient (DKK 2002 values)

Cost element	Undiscounted		Discounted 3%		Discounted 6%	
Direct costs	DKK	%	**DKK**	**%**	DKK	%
Diagnosis	1.113	0,23%	**1.113**	**0,38%**	1.113	0,56%
Daily treatment	64.172	13,47%	**39.558**	**13,58%**	27.227	13,71%
Total	65.285	13,71%	**40.671**	**13,96%**	28.341	14,27%
Indirect costs						
Production loss	32.400	6,80%	**19.753**	**6,78%**	13.418	6,76%
Welfare loss	378.673	79,49%	**230.864**	**79,26%**	156.818	78,97%
Total	411.074	86,29%	**250.617**	**86,04%**	170.236	85,73%
Total costs	476.359	100,00%	**291.288**	**100,00%**	198.577	100,00%

Starting age for contact allergy: 40 years old
Expected remaining lifetime : 38 years (Statistics Denmark (2003a))

The unit cost may seem rather high. This is to a large extent due to the fact that the disease is chronic, and following this, costs will arise each year of the remaining lifetime from the day of diagnosis settlement.

The welfare loss expresses the individual's willingness to pay to avoid the disease. Another way to look at this is the compensation paid by insurance companies to individuals with work related eczemas. The average compensation per person with work related eczema is DKK 66,976 (2002 value) (Sundhedsstyrelsen 2001). The costs of compensation are rather small compared to the value of the individual welfare loss which is DKK 230,864 (3% discount rate). One explanation for this deviation is that insurance companies do only pay compensation for damages which can be documented. Therefore, the individual WTP in practice is likely to be higher than the compensation paid by the insurance companies.

When costs of compensation are added to the direct health care costs, the total lifetime costs per person are 107,648, when using a 3% discount rate. This amount expresses the costs directly paid by the society.

In the section below, an example of how the unit cost estimate may be used in economic assessment is given by performing a, mainly illustrative, calculation of health benefit related to the policy initiative on Nickel in 1989.

7.8 Example of unit cost application: Nickel Allergy

This section is intended to give an illustrative example of how the estimated unit cost values may be used in an economic assessment of a chemical policy initiative.

In the following, we illustrate how an economic assessment of the health benefits following the policy initiative could have been carried out using the unit cost estimate developed in the present project. Although, the example is carried out first of all with the purpose of illustrating the applicability of using the estimated unit health benefit values, the example is based on what can be seen as the best available empirical basis. In this way, the example also illustrates the difficulties and uncertainties of making policy analyses that includes benefit assessments.

The data regarding the number of nickel cases are to be seen as guesstimates. The difficulty of establishing the impact pathway and quantifying the number of diseases is often the main constraint on the quality of benefit assessment. It is also the case here that such knowledge is not present. Thus, the data used

here are very uncertain, although the order of magnitude is believed to be realistic.

Nickel is the most frequent cause of contact allergy. Scandinavian surveys from the 1980's showed that approximately 20% of all women were allergic to nickel. In order to reduce this negative health effect, a statutory order limiting the permitted release of nickel from metal objects intended for close contact with the skin such as earrings, spectacle frames and buttons came into force in Denmark in 1989 (and followed by a revision in 1991).

7.8.1 Scenario definition

First, the policy initiative must be carefully defined along with a definition of the baseline of the assessment, which in most cases refers to the situation if the initiative had not been realised.

The policy initiative, reflected in the alternative scenario, is a situation where the statutory order on Nickel is implemented and complied with from 1989 and each year from this date.

The base line is defined as the situation without the statutory order. Here, it is assumed that nickel will be used in the same amount as before 1989 during each year from that date.

In reality the time horizon of the calculation should be infinite. Due to the discounting of future effects, however, effects arising far in the future have relatively little importance for the total result. Furthermore, effects arising far in the future are subject to relative high uncertainty. For these reasons, therefore, the time horizon of the present case calculation has been set to 20 years.

7.8.2 Mapping of impacts

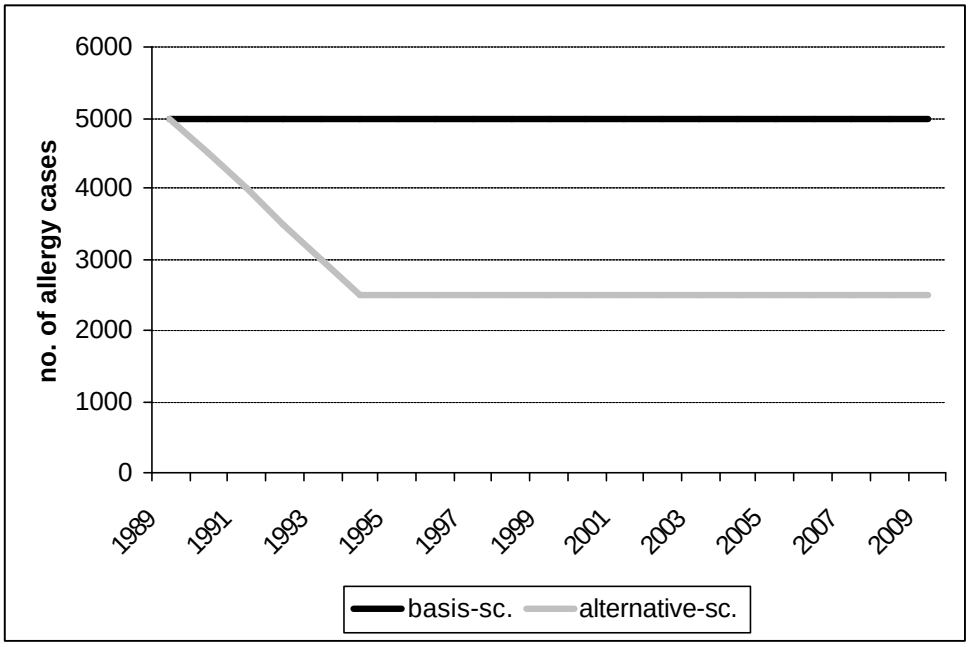
The assumptions regarding development of number of nickel allergy cases under basis and alternative scenario are based on information from Department of Dermatology, combined with rough assumption made by the consultant for this purpose.

On the benefit side the effect of the initiative was expected to be fewer cases of nickel allergy. In baseline, approximately 5,000 new cases of nickel allergy are assumed to be expected yearly. For simplicity is assumed that this number would be constant over the entire time horizon

In the alternative scenario it is assumed that the number of cases decreases with 50%, resulting 2,500 avoided cases of nickel allergy yearly. The full effect of the statutory order, however, is not expected to be seen before a number of years, 5 years assumed here, meaning that the full effect is seen from 1994. The development in number of cases of nickel allergy under basis and alternative scenario is seen in Figure 7-2 below[13].

[13] This development pattern is based on expert judgement but including rough assumptions made by the consultant for the present purpose.

Figure 7-2: Assumed development in no. of allergy cases under basis and alt. scenario



7.8.3 Valuation of impacts

The health benefits are valued by the unit cost estimated in the present project. The estimated unit value of DKK 291,288 includes lifetime costs for the average patient. The benefits each year using a discount rate of 3% is seen in Table 7-4 below.

Table 7-4: NPV of health benefits from reducing use of nickel, million DKK, 2002 prices

	1990	*1991*	*1992*	*1993*	*1994*	*1995*	.....	*2008*	*2009*	*Total*
Direct costs	20	39	58	74	90	88	.....	60	58	1361
Welfare loss	115	224	326	423	513	498	.....	339	329	7723
Production loss	10	19	28	36	44	43	.....	29	28	661
Total	146	283	412	533	647	628	.....	428	415	9744

Adding the annual benefit from avoided allergy cases over the time horizon of 20 years results in a net total present value (NPV) of DKK 9.7 billion.

Along with this assessment, a sensitivity analyses should be carried out. In Table 7-5 the total assessment result is seen for low, best and high unit cost estimate. The assumption behind the estimates for the low and the high unit cost is given in section 10.2.2.

Table 7-5: Low and high NPV of health benefits, M. DKK, 2002-prices

Low unit cost estimate	Best unit cost estimate	High unit cost estimate
2,700	9,700	22,900

The assessment thus shows that the total benefits following the policy initiative are within the range of m. DKK 2,700 and 22,900. As the number of avoided cases of nickel allergy is also subject to significant uncertainty, the total range of values could be wider than indicated in the table. However, if the range of uncertainty for the number of avoided cases is not much higher

than a factor of 2 to 3 and the uncertainty in estimating the number of cases is independent of the uncertainty of the unit cost estimates, then the total range of expected benefits is not much different from the range illustrated in Table 7-5.

The example shows the usefulness of having unit costs per disease. Undertaking cost-benefit analysis of new policy proposals require that the whole impact pathways can be described and the final effects in terms of a number of reduced diseases can be quantified. In the example such estimation was possible, although highly uncertain. In order cases, the unit costs can be use to perform a backward calculation. If the cost of a new regulation is known, then the number of cases of the disease that has to be avoided for the benefit to excess costs can be estimated.

8 Lung cancer

Lung cancer is defined as a malignancy within the lungs and may be localized or has spread to multiple sites (Bennet and Plum (1996)).

8.1 Definition

The lung cancers analysed in this section are classified as C33-C34 in the ICD-10 classification of diseases. Following this classification, the definition of lung cancer also includes tracheal cancer, a rare type of cancer.

8.2 Chemicals associated with Lung Cancer

The far predominant cause of lung cancer is smoking. However, a number of chemicals are known or suspected to cause lung cancer as well (COI Handbook (2002)). EPA has developed a list of chemicals known or suspected to cause lung cancer. Most chemicals were carcinogenic in animal studies. These studies do not provide organ-specific data because it is not generally assumed that cancer induction will necessary occur at the site in humans as in animals (COI Handbook (2002))[14]. Hence, it is difficult to determine specific chemicals with specific types of cancer.

However in Denmark, Arbejdsmiljøfonden has assessed the cancer evidence in related to chemicals (Hansen et al. (1998)). The overall conclusions in relation to lung cancer were that, there was a significant increased risk of lung cancer for epichlorhydrin and chlorinated paraffins.

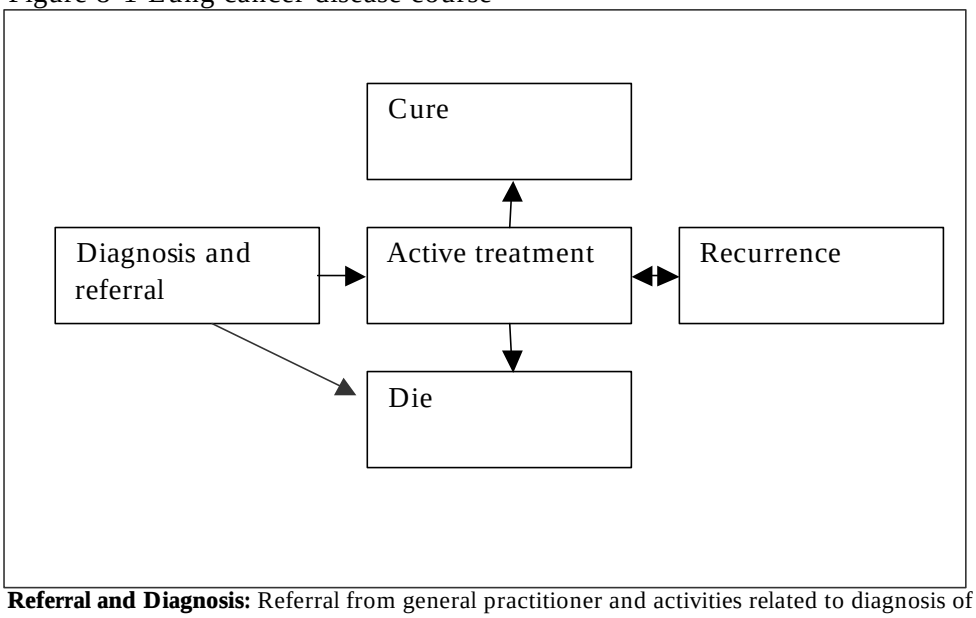
8.3 Disease course

The disease course of lung cancer is illustrated in Figure 8-1. Treatment of lung cancer can be divided into the following states: Referral and Diagnosis, Active treatment, Cure, Recurrence and Death.[15]

[14] The entire list of chemicals known or suspected to cause lung cancer is available at http://www.epa.gov/oppt/coi/toc.html. See Chapter II.5.

[15] Based on Olivier et al. (2001), Behandling af lungkræft (Kræftens Bekæmpelse (2003a)), and Braud et al. (2001).

Figure 8-1 Lung cancer disease course



Referral and Diagnosis: Referral from general practitioner and activities related to diagnosis of the patient
Active treatment: Activities related to treatment of the patient (chemotherapy, surgery, etc.)
Die: Death due to lung cancer
Cure: The patient is cured from lung cancer
Recurrence: After treatment, lung cancer recur

The treatment depends on the type of lung cancer, the patient's ability to receive the different kind of therapy, and on the stage of the disease.

In order to estimate the lifetime costs it is necessary to provide data regarding the probabilities of moving from one stage to another. Here, this is done by utilising a Markov model. See section 4.2.1 for a further description.

The Markov model for lung cancer is divided in three states:

- Survive
- Cure
- Death

The utilised Markov model is a so called time dependent model where the transition probabilities vary over time.

The state *Survive* is the state where a person has been diagnosed as having lung cancer but is neither dead nor cured. This state includes cost of diagnosis, referral, active treatment and recurrence. In the state *Death*, the person is dead from lung cancer. This state includes treatment costs the year in which the person dies. In the state *Cure* the person is cured from lung cancer. The states Death and Cure are absorbing states (i.e. when a person has entered the state, it is not possible to leave).

Transition probabilities are derived from relative survival data for Danish people with lung cancer (Storm and Engholm (2002)). The relative survival data can be interpreted as the excess mortality from lung cancer. The available data cover relative survival for 1, 5 and 10 years following the diagnosis. The relative survival for these years is 23, 7 and 4 % respectively. As relative survival data beyond the 10^{th} years were not available, and the impact of extending the model beyond this point is marginal, the simulation

was done for 10 years. The 4 % being alive after 10 years are assumed to be cured.

The probability of moving from Survive to Death is taken directly from the relative survival data. The probability of moving from Survive to Cure is modelled from the 4% being alive after 10 years.

The resulting Markov simulation of the cohort is shown in Table 8-1. After 10 years 4% are Cured (40/1000=0.04) and 96% are in the state Death (960/1000 = 0.96).

Table 8-1 Time dependent markov cohort simulation of lung cancer survival

Cycle	Cure	Survive	Death	Total
0		1,000		
1	19	211	770	1,000
2	21	150	829	1,000
3	23	104	873	1,000
4	25	70	906	1,000
5	27	43	930	1,000
6	29	34	937	1,000
7	31	25	944	1,000
8	34	16	950	1,000
9	37	8	955	1,000
10	40	0	960	1,000

Cycle A cycle has the length of one year
Cure The person is cured from lung cancer
Death The person is dead from lung cancer
Total Total number of persons in the cohort

The expected costs are obtained by assigning costs to each person in each state, and then summing over all persons over the 10 year simulation period and dividing by the total cohort number. It is assumed that the persons cured and dying are entering these states uniformly over the year, meaning that they enter the states after 6 months in average. To the extent possible this is taken into account in the estimation of the costs.

8.4 Direct health care costs

Direct lifetime costs are estimated from a large scale register study by (Gundgaard et al. (2002)). The advantage of register data is that they reflect actual use of resources. Therefore, the lifetime costs of lung cancer will be estimated from these data complemented with cost estimates for other services not included in this study.

Cost of hospital and primary care

The costs estimates from Gundgaard et al. (2002) cover hospital and primary care services. The study is based on a 20% sample of the Danish population. Data on use of health care resources were retrieved from the Prevention Register at Statistics Denmark, the Cancer Register and combined through the unique personal identification number.

The costs are estimated by following patients with the diagnosis ICD-10 C33-C34 during the years 1996 and 1997. These cost data reflect average costs of a person with lung cancer. Hence, also costs not related to the lung cancer per

see are also included. Incremental costs due to lung cancer were estimated by subtracting average costs per person not having lung cancer from these values.

The cost data include the following health care resources: In-patient hospital services, and out-patient hospital services (ambulatory visits, emergency room visits). Costs were estimated using the 1997 version of the Danish DRG-system. Costs of primary health care services coved through the health care reimbursement scheme were also included. Costs for 10 years following the diagnosis were estimated from cross sectional data. Combining these costs estimates with Danish relative survival rates in the Markov model expected costs for a person with lung cancer were estimated.

Total expected costs hospital and primary care services are DKK 113,840 3% discount rate. There is not much difference whether 3 or 6% discount rates are used as most of the costs falls within the first years.

Table 8-2 Total direct costs over 10 years (DKK 2002 values)

Direct total costs	Undiscounted	**Discounted 3%**	Discounted 6%
Hospital services	114,207	**112,898**	111,747
Primary care services	979	**942**	910
Total direct costs	115,186	113,840	112,657

Results based on Markov simulation.
Hospital services include inpatient and outpatient services.
Primary care services includes care covered through the Health Care Reimbursement Scheme
Costs for Hospital and Primary care services were estimated using the DRG system

The costs estimate for hospital services is higher than the estimate recently used by the Environmental Assessment Institute (DKK 66,000 in 2002 value) (Petersen et al. (2003)). The source for this estimate is Rasmussen et al. (2000). In their study only costs which can be directly attributed to smoking are included. The cost estimate in this report is based on Gundgaard et al. (2002) which include all costs for patients with the main diagnoses C43 and C44 irrespective whether the reason is smoking or another. Therefore, the scope of the analysis by Gundgaard et al. (2002) is broader and hence, yields a higher cost estimate per person. In addition to this, the study by Gundgaard et al. (2002) uses a later version of the DRG-system as well as the registration of ambulatory services has improved since the study by Rasmussen et al. (2000).

Cost of terminal care

Costs of terminal care outside the hospitals were not included in the study by Gundgaard et al. (2002). Costs of terminal care were estimated using data from the report concerning palliative efforts in counties and municipalities in Denmark (Amtsrådsforeningen et al. (2000)). According to this report, 49.7% of the patients die at the hospital. Costs of these patients are included in the costs estimates by Gundgaard et al. (2002). However, 24.5% die at nursing homes or other institutions, 22.2% at home and 3.6% at other places are not included. It is possible to estimate costs for those who die at home or at nursing homes. The 3.6% dying elsewhere are omitted in the calculations.

Table 8-3 Direct total costs of dying outside the hospital (DKK 2002 values)

Direct total costs	Value	Total costs	Source
Institution			
Average number of days	23		23
Cost per day	3,842		23
Total costs		88,357	
Percentage of patients	25%		23
Expected costs		21,648	
Home			
Average number of days	23		23
Cost per day	1,947		24
Total costs		44,771	
Percentage of patients	22%		23
Expected costs		9,939	
Total costs		**31,587**	

Institution includes nursing homes, hospices and other institutions
Home is when the patient dies at home. Palliative care is given by nurses etc.
Sources The number refers to the source for the calculation. See appendix 1 with list of sources for the calculations.

The total costs of Terminal care are DKK 31,587 for a person dying outside the hospitals. When multiplying this cost estimate with the probability of dying, we can calculate the expected discounted costs of dying at institutions and at home.

The total expected direct costs of lung cancer are DKK 143,685 using 3 % discount rate (Table 8-4). Costs of terminal care in Table 8-4 do not correspond exactly to costs of terminal care in Table 8-3. The reason for this is that, the estimations in Table 8-4 are based on the Markov simulation where 4% of the patients survive. Therefore, the cost estimate in Table 8-4 is slightly lower.

Table 8-4 Total direct costs of lung cancer (DKK 2002 values)

Direct total costs	Undiscounted	Discounted 3%	Discounted 6%
Hospital services	114,207	**112,898**	111,747
Primary care services	979	**942**	910
Terminal care	30,323	**29,845**	29,433
Total direct costs	145,510	**143,685**	142,090

Results based on Markov simulation.

8.5 Individual welfare Loss

In the estimation of the welfare loss we distinguish between people that are cured and people that eventually die from lung cancer.

Of main importance is the welfare loss of lung cancer death. This is estimated by the value of a statistic life of *DKK 9.64 million*., presented in section 4.3.8.

In the case of people that are cured from the cancer, there is very limited empircal evidence on WTP estimates for non-fatal cancers. It is obviously lower than the WTP for the fatal cases, but probable also not insignificant, as the patient will not know the deasise cource in advance. In an EU study on air

pollution, a value of 50% of the WTP for fatal cancers have been used[16]. They emphisize the high level of uncertainty attached to this value.

The choice of a value for the WTP for the non-fatal lung cancers is quite limited an the total result. A value of 50 % of the WTP for a statisitical life amounts to less than 2% of the total direct and indirect costs. Although, there is limited evidence regarding this aspect, it is still an element that should be included. Thus, the value of 50% is used.

The total welfare loss of lung-cancer must be a weighted average of the estimate of non-fatal lung cancer and cancer death respectively. This is estimated to be *DKK 9.4 million*. (at a discount factor of 3%), taken into account the average duration of the disease for person cured and the time of appearance of the death.

It should be mentioned that the estimate of non-fatal lung cancer is subject to a high degree of uncertainty. As seen above, however, it does only to a limited extent affect the weighted average of lung cancer welfare loss estimate.

8.6 Production loss

No information on the absence from work in connection with lung cancer has been found in the literature. For the present purpose it is assumed that a patient that is cured during a certain year will be absent 50% of the day during the period of illness, which is 6 months in average. Following this, he will be absent 25% of the year, during which he is cured. Survivors likewise are assumed to be absent 50% of the time, and the period of illness lasts the whole year. For people dying within a certain year it is assumed that they are 100% absent from work. Since gross production loss should only be included until the day of death, it is taken into account, that people in average live 6 months within the year of death.

Besides this, the net production loss due to mortality must be included. A person dying implies a net production loss to the society during the expected life time remaining in case of no lung cancer. For the present purpose it is assumed that the average age of patient achieving the diagnosis of lung cancer (in year 1) is 50 years. According to Statistics Denmark (2003a) the expected remaining life time at this age is 29 years. Thus, each patient that eventually dies will result in a net production loss from the day of death (in average after 6 months within the year of death) until the day he would have turned 79 years.

The average production loss per case of lung cancer is estimated to *DKK 253,616*.

8.7 Unit cost estimate

The total result of the unit cost estimation of lung cancer is seen in Table 8-5 below.

[16] AEA Technology (2001), page 71-72.

Table 8-5: Total unit cost estimate for lung cancer (DKK 2002 values)

Cost component	Undiscounted		Discounted 3%		Discounted 6%	
Direct total costs						
Hospital services	114.207	1,13%	**112.898**	**1,17%**	111.747	1,17%
Primary care services	979	0,01%	**942**	**0,01%**	910	0,01%
Terminal care	30.323	0,30%	**29.845**	**0,31%**	29.433	0,31%
Total direct costs	145.510	**1,44%**	**143.685**	**1,48%**	142.090	**1,49%**
Indirect costs						
Production loss	529.447	5,23%	**253.616**	**2,62%**	235.802	2,48%
Welfare loss	9.447.197	93,33%	**9.286.110**	**95,90%**	9.147.796	96,03%
Total indirect costs	9.976.645	98,56%	**9.539.726**	98,52%	9.383.598	98,51%
Total costs	10.122.154	100,00%	**9.683.411**	100,00%	9.525.689	100,00%

At a discount rate of 3% the unit cost is DKK 9,683,411. The individual welfare loss contributes with no less than 95.9% of the cost, being far the most important cost element. This is mainly due to the high mortality risk of lung cancer along with the relatively high value of a statistical life used for valuation.

It is further seen that choice of discount factor does not change the result very much, mainly do to the fact that the average remaining lifetime at the time of diagnosis settlement is rather low (during the first year no less than 77% of the patients die) and following this most cost will fall within the first year.

9 Skin cancer

Skin cancer is defined as a malignant melanocytic tumor arising in the skin. Often skin cancer is divided into two main groups. (1) Non-melanoma and (2) melanoma skin cancer known as 'birthmark cancer'. Whereas no relation between chemicals and non-melanoma skin cancer exists, certain types of chemicals may induce non-melanoma skin cancer. Therefore the focus here will be on non-melanoma skin cancer[17].

The two main cancer groups within non-melanoma skin cancer are basal cell carcinoma and squamous cell carcinoma. The latter also called spinocelluaire carcinoma. US data shows that Squamous cell carcinoma is responsible for 20% of the non-melanoma skin cancer cases, and basal cell carcinoma is responsible for approximately 75% of the cases (Chen et al. (2001)). The remaining 5% are other types of non-melanoma skin cancers. The incidence of non-melanoma skin cancer in Denmark is increasing (Sundhedsstyrelsen 2003a; 2003b).

Chemicals can induce squamous cell carcinoma. The available clinical data do not distinguish between the different types of non melanoma skin cancers (Sundhedsstyrelsen 2003a; 2003b). The reason for this is that registration of cancers is based on the ICD10. It is only registered whether the cancer is melanoma or non-melanoma and where it is located. This can be the reason why the international literature on costs of non-melanoma cancers is not segmented according to variety (e.g. Housman et al. (2003); Chen et al. (2001))). Furthermore, the literature on chemicals related to non-melanoma skin cancer is not segmented according to variety either (e.g. EU Commission (2003); Hansen et al. (1998)). Therefore, the costs estimations are made for the general group 'non-melanoma skin cancer'.

9.1 Definition

Non-melanoma skin cancer is defined as C44 (Non-melanoma skin cancer) ICD-10 classification of diseases.

It is assumed that all patients are treated within one year and that non-melanoma is not fatal. Even though a number of patients are likely to die from the non-melanoma skin cancer, Danish data on survival for non-melanoma skin cancer show a higher relative survival probability than the background population (Storm and Engholm (2002)). Therefore, fatality is not included in the analysis.

9.2 Chemicals associated with Skin Cancer

The far most important reason for skin cancer in general is UV radiation of the skin from the sun. In relation to chemicals, there is no clinical evidence showing a direct relation between skin cancer and chemicals. However, animal studies and observational human studies indicate that exposure to certain

[17] Indirectly, chemicals reducing the ozone layer may cause both types of skin cancer through increased UV radiation of the skin.

chemicals, such as coal tar pitch, mineral oil, and creosote increases the relative risk of skin cancer (Merck (1998); Andersen et al. (1994)).

9.3 Direct health care costs

Estimation of direct health care costs are based partly on the incidence based approach and partly on the prevalence based approach. Costs for hospital services are based on the prevalence approach where as costs for primary care services are based on the incidence approach.

According to Drzewiecki (2003), 30% of the patients are treated in the primary care sector only. 70% of the patients are visited in the primary care sector and referred to treatment in the secondary sector (hospital sector).

Costs for patients treated in the hospital sector

Costs of hospital services are estimated from the average number of discharges for inpatient and outpatient hospital services (Table 9-1).

Table 9-1 Total treatment costs for patients with non-melanoma skin cancer treated in the hospital sector (DKK 2002 values)

Service	Value	Costs	Total costs	Sources
Primary care services				
GP Consultations	1	105	105	(34;9)
1st consultation MS	1	502	502	(34;13)
Costs per person			607	
Secondary care services				
Inpatient hospital service	1,334.00	19,610	26,159,740	(37)
Outpatient hospital service	21,891.00	2,692	58,930,572	(37)
Total costs			85,090,312	
Incidence	5,637			(35)
Costs per person			15,095	
Total costs of primary and hospital services			15,702	
Percentage of patients	70%			
Expected costs			10,991	

Sources The first number refers to the source for the number of services or percentage. The second number refers to the source for the cost per service. See appendix 1 with list of sources for the calculations.

Before a patient is referred to a hospital, the patient will on average have one consultation at the GP and one at the MS.

Total costs of hospital services are approximately DKK 85 millions. The costs per person are found by dividing total hospital costs with the incidence for non-melanoma skin cancer. Hence, of the persons admitted to the hospitals, the costs per person are approximately DKK 15,000. Total expected costs are found by multiplying total costs with the percentage of patients referred to hospitals. Hence, total expected costs for persons treated at hospitals are 10,991 per person.

Costs of treating a person in the primary care sector are estimated using expert input as no data regarding use of these services are available (Table 9-2).

Table 9-2 Total direct costs for patients with non-melanoma skin cancer treated in the primary care sector (DKK 2002 values)

Primary care services	Value	Costs	Total costs	Sources
General Practitioner				
GP Consultations	3	105	315	(34;9)
Follow-up visits	6		594	
Total costs			910	
Percentage treated at GP	15%			
Expected costs			136	
Medical Specialist				
GP Consultations	1	105	105	(34;13)
1st consultation MS	1	502	502	(34;13)
2nd consultation MS	1	276	276	(34;13)
Subsequent consultations MS	1	135	135	(34;13)
Follow-up visits	6		2,841	(34;13)
Recurrence	17%		606	(34;13)
Total			4,465	
Percentage treated at MS	85%			(34)
Expected costs			3,795	
Total costs of primary care services per person			3,931	
Percentage of patients	30%			(34)
Expected costs			1,179	

Sources The first number refers to source for the number of services. The second number refers to source for the costs per service. See appendix 1 with list of sources for the calculations.

15% of the patients treated in the primary care sector are treated at the GP whereas 85% are treated at the MS (Drzewiecki (2003)). In both cases, the patient will have 6 follow-up visits over the following 3 years. Using a discount rate of 3%, the costs of 6 follow-up visits are DKK 594 and 2,841 for GP and MS respectively. Furthermore, 1/6 of the patients will have recurrence of the non-melanoma skin cancer (Drzewiecki (2003)). Recurrence is assumed on average to take place in the second year following the diagnosis. Using a discount rate of 3%, costs of recurrence are estimated to be DKK 606 ((1/6 * 2,841)/1.03^2). Total costs for patients treated in the primary care sector are DKK 3,795. Hence, expected costs are DKK 1,179 when taking into account that this is only 30% of the patients.

Total direct costs are estimated by adding costs of primary and hospital services together (Table 9-3).

Table 9-3 Total direct costs per person with non-melanoma skin cancer (DKK 2002 values)

Variable		Costs
Primary care sector		1,179
Primary and secondary care sector		10,991
Costs per person		**12,171**

Total expected costs per person are estimated to be approximately DKK 12,000.

9.4 Individual welfare loss

Compared to other types of cancer many cases of non-fatal skin cancer are relatively easily cured without to much pain and suffering for the patient. Furthermore the average duration of the disease course is relatively short (less than one year).

One of the elements to be included in the individual welfare loss of skin cancer is the risk of permanent scars. According to Drzewiecki (2003) app. 70% of all inpatient treatments results in permanent scars. It is estimated that 70-75% of the cases appear in the face/neck and following this, scars will be difficult to cover.

Only very few studies on the WTP to avoid skin cancer are available. This include following as best options for benefit transfer:

- **Murdoch and Thayer (1990)** estimate WTP for skin cancer by estimating the private benefits from savings in defensive expenditures for sun protection products from initiatives protecting the ozone layer.

  First, they forecast the expected ozone depletion during the period 2000-2050 as well as the expected increase in number of skin cancers. Then they estimate the need for sun protection products in order to neutralise the negative effect on human health from the ozone depletion. Based on information on the price on sun protection products this result in the total expenditures needed to offset the negative effect of the ozone depletion.

  The additional expenditures on sun protection products amounts USD 87.7 billion over the entire time horizon (undiscounted), which is expected to save 2.96 m. cases of non-melanoma skin cancer. This results in a value of app. USD 30,000 per skin cancer case (1985 prices).

  Converted into DKK 2002-prices, this amounts DKK 301,655 and corrected for differences in income and purchasing power between Denmark and US it results in a value of app. DKK 230,000.

  There are several reasons why benefit transfer from this study is critical. First, benefit transfer from an American study into a Danish context may be critical, along with the fact that the study is rather old. Secondly crucial elements of the study may be questioned, such as number of skin cancers following ozone layer depletion and the degree of protection from sun lotion.

- **According to Pearce (2000)** An Australian contingent valuation study from 1992 showed that WTP of avoiding skin cancer would lie in the range DKK 56,000 - 1,200,000 (2002-prices), which is a rather large interval, however. Furthermore, it is unclear how these values have been derived.

- **Extern E** provides estimates for welfare loss of non-fatal cancer in general. This estimate is around DKK 3.6 million and is probably not suitable for skin cancer, where the welfare loss must be expected to be somehow lower in perspective of the normally rather short and light disease course. Furthermore it is not very well documented how the estimate has been provided, and therefore what it covers.

As seen from the descriptions above, the few existing studies of the individual welfare loss of skin cancer do not seem to be very suitable for benefit transfer for the present purpose. Our best suggestion is to use the value from Murdoch and Thayer estimate, being aware of its clear weakness. It may also be chosen to use the cost estimate without the individual welfare loss in a quantitative form.

9.5 Production loss

No statistics on the degree of absence due to skin cancer is available. Based on data on the number of various treatments combined with expert judgement (Drzewiecki (2003)), the number of days of sickness following Skin cancer has been estimated as seen in Table 9-4 below.

Table 9-4: number of days lost per skin cancer patient

	Working days	All days	Total lost days of production
Inpatient	0.2	4.1	3.1
Outpatient	3.9	4.0	6.6
GP treatment	2.0	1.0	2.7
Total	6.1	9.1	**12.4**

The number on lost days of production is a result of following data and assumptions:

Each inpatient hospital service of 4.5 days in average, and the incidence of hospitalization in connection with skin cancer is 23.7%. In addition to this it is assumed that each hospitalization is followed by a period of illness of 14 days in average ((Drzewiecki (2003)). It is further assumed that all days of illness may fall on working days as well as non-working days, except for one day of hositalization, namely the day of operation, which will always fall on a working day.

Each patient receives outpatient hospital services 3.9 times in average. In average, one of these times is assumed to include operation. Each outpatient operation is assumed to result in additional 4 days of illness at home ((Drzewiecki (2003)). Each time of outpatient hospital service is assumed to result in a day absence from work. The 4 additional days may fall on working as well as non-working days.

Each patient has 9 visits at the GP in average. It is here assumed to result in 3 days of absence from work.

With a production loss value of DKK 533 per day the average production loss value is DKK 6,625 per skin cancer patient.

9.6 Unit cost estimate

The total unit cost estimate is seen in Table 9-5 below. The total unit cost of skin cancer is DKK249,424. Again, the welfare loss is seen to be the far most important cost element contributing with 92% of the total costs. However, as described above, the estimation of the individual welfare loss is very uncertain, which makes the total unit cost estimate very uncertain as well.

Table 9-5: Unit cost estimate, non-melanoma skin cancer, DKK, 2002-prices

Component	Costs	
Primary care sector	1,179	0%
Primary and secondary care sector	10,991	4%
Total direct costs	12,171	5%
Welfare loss	230,629	92%
Production loss	6,625	3%
Total indirect costs	237,253	95%
Total economic costs	249,424	100%

Primary care sector are costs for those patients only treated in the primary sector
Primary and secondary sector are costs for those patients treated in both the primary and secondary sector

10 Unit costs - summary of results

This chapter summarises and discusses the estimates that have been developed through chapter 3-7. Furthermore, the aim is to set up low and high unit cost estimates for each disease based on the discovered uncertainties.

10.1 Summary of results

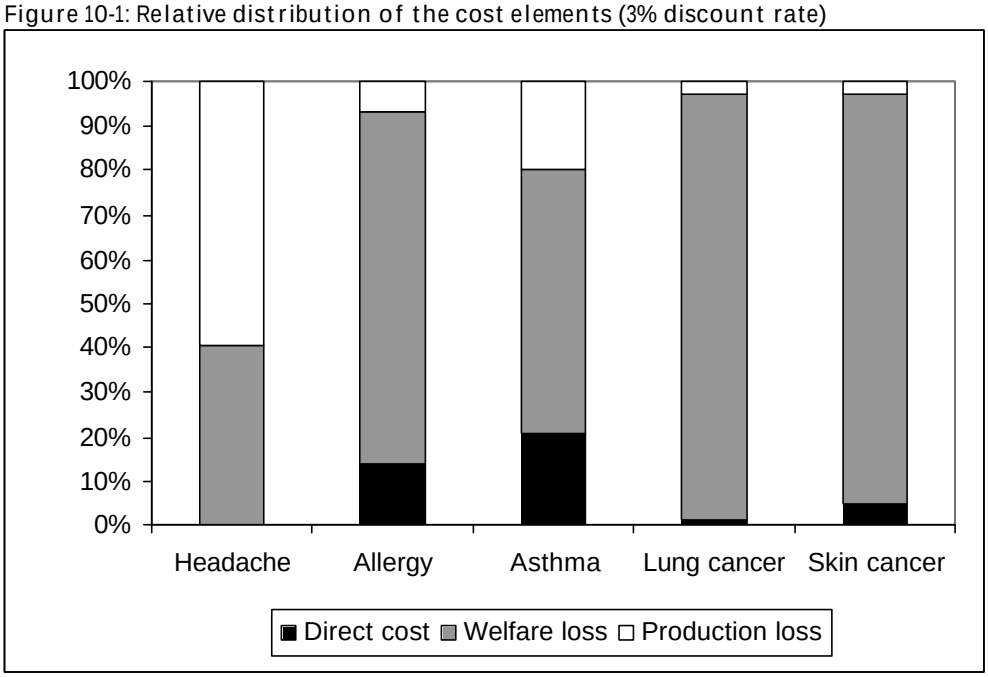
Table 10-1below summarises the results from the estimations in chapter 3 to 7. The relative distribution of the costs is seen in

Table 10-1: Summary of unit cost estimates, DKK, 2002-prices

		Discount rate: 3%	Discount rate: 6%
Headache (cost per episode)	Direct costs	1	
	Welfare loss	179	
	Production loss	184	
	Total unit cost	**364**	
Contact allergy (cost per patient)	Direct costs	40,671	28,341
	Welfare loss	230,864	156,818
	Production loss	19,753	13,418
	Total unit cost	**291,288**	**198,577**
Asthma (cost per attack)	Direct costs	417	
	Welfare loss	1,186	
	Production loss	391	
	Total unit cost	**1,993**	
Lung cancer (cost per patient)	Direct costs	143,685	142,090
	Welfare loss	9.286.110	9.147.796
	Production loss	253,616	235,802
	Total unit cost	**9.683.411**	**9.525.689**
Skin cancer (cost per patient)	Direct costs	12,171	
	Welfare loss	230,629	
	Production loss	6,625	
	Total unit cost	**249,424**	

In general it is seen that the indirect costs count for the major part of all cost estimates, ranging from 79% to 99.7% of the total unit costs. Especially, the individual welfare loss becomes of major importance counting for 40% to 96% of the cost estimate

Figure 10-1: Relative distribution of the cost elements (3% discount rate)

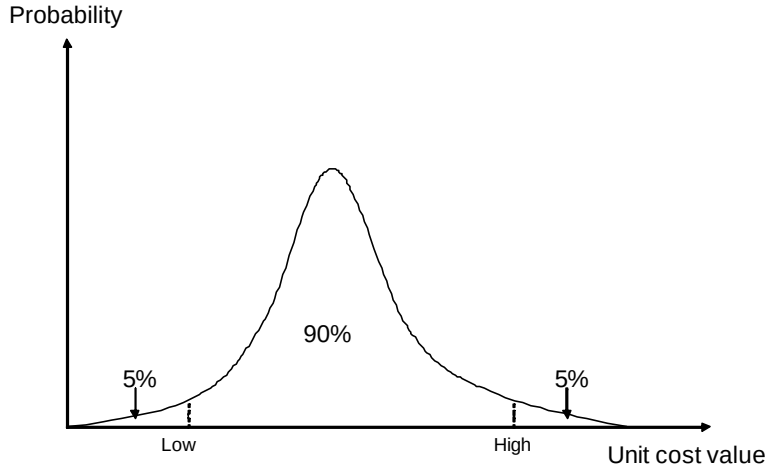


10.2 Uncertainties - Low and high unit cost estimates

Low and high unit cost estimates may be useful in connection with economic assessments, and is provided here, by a heuretic approach. This basically means, that uncertainties are analysed by a combination of information of uncertainties of various parameters based on various sources combined with the consultant's judgement. Ideally, high and low estimates should be developed through complex mathematical simulations by combining uncertainties of all uncertain parameters. This, however, demands extensive data and is rather complex, and will not be possible within the present project.

The low and high unit cost estimates are to reflect the 5% and the 95% percentiles respectively. Thus, the low estimate illustrates the level at which the "true" unit cost value with 5% probability will be equal to or lower than. Likewise, the high cost estimate illustrates the level at which the "true" value with 5% probability will be equal to or higher than. This principle is illustrated in Figure 10-2 below.

Figure 10-2: Illustration of the principle behind low and high estimates



The present approach is divided in two steps. First, the critical elements of the unit cost estimates are identified from two criteria: Their relative importance and their degree of uncertainty. Secondly, high and low values of the identified critical elements are set and the effect on the unit cost estimates is analysed.

10.2.1 Identification of critical elements

The assessment of relative importance and degree of uncertainty is done for each of the three main elements: direct costs, welfare loss and production loss. Each element is assigned a weight (on a ordinal scale) from 0 (unimportant/no uncertainty) to 3 (very important/large uncertainty). The assessment results are relative to each other among cost elements and diseases.

Below, the assessment of importance and uncertainty is presented for each disease by a table supplemented by bullets explaining the assessment.

Headache:

- Direct costs: of no importance, but rather uncertain
- Welfare loss: Counts for 40% of the unit cost value and thus of some importance. Some degree of uncertainty, due to a WTP survey from Norway. However, definition of the disease in the present study is identical with definition of the WTP survey.
- Production loss: Counts for 60% of the unit cost value, meaning great importance. The extent of absence from work is rather uncertain, resulting in uncertainty of 2.

Table 10-2: headache

Cost element	Relative importance	degree of uncertainty
Direct costs	0	2
Welfare loss	2	2
Production loss	3	2

Contact allergy

- Direct cost: Is of little importance and subject to relatively little uncertainty
- Welfare loss: Counts for 79% of the unit cost value and thus of great importance. Uncertainty is high, due to no precise WTP estimate available (WTP of a "symptom day" used) as well as uncertainty about the number of symptom days per year.
- Production loss: Of little importance and some uncertainty (number of days of absence may be underestimated).

Table 10-3: Contact allergy

Cost element	Relative importance	degree of uncertainty
Direct costs	1	1
Welfare loss	3	3
Production loss	1	2

Asthma

- Direct cost: Of little importance and subject to relatively little uncertainty
- Welfare loss: Counts for 59% of the unit cost value and thus of great importance. Rather good WTP estimate but taken from a Norwegian survey, and benefit transfer is always subject to some uncertainty
- Production loss: Of little importance and little uncertainty due to high quality data on degree of absence

Table 10-4: Asthma

Cost element	Relative importance	degree of uncertainty
Direct costs	1	1
Welfare loss	3	2
Production loss	1	1

Lung cancer

- Direct cost: Of little importance and subject to relatively little uncertainty
- Welfare loss: Counts for 96% of the unit cost value and is thus of great importance. Very large uncertainty due to benefit transfer from a Sicilian study, where the context and approach are uncertain, combined with the great uncertainty of the value of a statistical life.
- Production loss: Is of little importance but subject to a high degree of uncertainty, since the extent of absence during the illness is unknown and thus based on guesstimates.

Table 10-5: Lung cancer

Cost element	Relative importance	degree of uncertainty
Direct costs	0	1
Welfare loss	3	3
Production loss	0	3

Skin cancer

- Direct cost: Of little importance and subject to relatively little uncertainty
- Welfare loss: Counts for 92% of the unit cost value and is thus of great importance. Very uncertain as described in chapter 9.4.
- Production loss: Of little importance but a certain degree of uncertainty, since no high quality data on the degree of absence has been found.

Table 10-6: Skin cancer

Cost element	Relative importance	degree of uncertainty
Direct costs	1	1
Welfare loss	3	3
Production loss	0	2

10.2.2 Assessment of low and high values

The low and high values are developed by setting up high and low values of each of the most important and uncertain parameters, relatively speaking and re-estimate the unit cost under combinations of these parameter values.

Headache

High and low cost estimates are derived from following assumptions:

- Welfare loss values are equal to best estimate -/+ 50%
- Degree of absence from work is assumed to be within the range 15% to 55%

Table 10-7: High and low unit cost estimates, headache (2002-prices)

	value, low estimate	value, best estimate	value, high estimate
Welfare loss	DKK 89	DKK 179	DKK 268
Degree of absence	15%	35%	55%
Unit cost estimate	**DKK 224**	**DKK 364**	**DKK 562**

Contact allergy

High and low cost estimates are derived from following assumptions:

- Low welfare loss value assumes no additional private expenditures for lotion etc. along with best WTP estimate minus 50%. High welfare loss value assumes no changes in private expenditures along with best WTP estimate plus 50%.

- Number of symptom days are set to 10% and 30% for low and high estimate respectively
- Number of days of absence set to 1 and 10 for low and high estimate respectively
- Average age of patient: Set to 50 years for estimation of low unit cost value and 30 years for high value.

Table 10-8: High and low unit cost estimates, contact allergy (2002-prices)

	value, low estimate	value, best estimate	value, high estimate
WTP value	DKK 50	DKK 100	DKK 150
Private exp.	0	2650	2650
no. of symptom days	10%	20%	30%
Days of absence	1	1.6	10
Av. age of patient	50 years	40 years	30 years
Unit cost estimate	**DKK 79,798**	**DKK 291,288**	**DKK 684,203**

Asthma

High and low cost estimates are derived from following assumptions:

- Low welfare loss values according to the lowest figure found in the literature (Extern E). High value set to + 50% of best estimate

Table 10-9: High and low unit cost estimates, Asthma (2002-prices)

	value, low estimate	value, best estimate	value, high estimate
Welfare loss	DKK 156	DKK 1,186	DKK 1,778
Unit cost estimate	**DKK 963**	**DKK 1993**	**DKK 2586**

Lung cancer

High and low cost estimates are derived from following assumptions:

- Welfare loss value for non-fatal lung cancer is set to 50% of estimate value of statistical life
- Value of a statistical life is set to DKK 1 m. and 10 m. as low and high value respectively partially based on values of a statistical life presented in DEPA (2003)

Table 10-10: High and low unit cost estimates, lung cancer (2002-prices)

	value, low estimate	value, best estimate	value, high estimate
Welfare loss, NFC	DKK 750,000	DKK 4,820,000	DKK 6,000,000
Value of a statistical life	DKK 1,500,000	DKK 9,640,000	DKK 12,000,000
Unit cost estimate	**DKK 1,842,235**	**DKK 9,683,411**	**DKK 11,956,774**

Skin cancer

High and low cost estimates are derived from following assumptions:

- Being very uncertain, the interval of the individual welfare loss is set to DKK 10,000 - DKK 500,000.

Table 10-11: High and low unit cost estimates, skin cancer (2002-prices)

	value, low estimate	value, best estimate	value, high estimate
Welfare loss	DKK 10,000	DKK 230,629	DKK 500,000
Unit cost estimate	**DKK 28,796**	**DKK 249,424**	**DKK 518,796**

10.3 Concluding remarks

The present study has provided unit cost estimates for selected chemical-related diseases. Even though the estimates include all elements of the economic costs seen from the society's point of view, estimation of the direct costs has been in focus. Since indirect costs, however, are of major importance relatively, there may be a need for further development of these estimates in a future study.

The major critical element, thus, seems to be the individual welfare loss values, here provided by benefit transfer. Since these values are of major importance for the total unit cost estimates it would be preferable to improve these values. Although it may be possible to improve the benefit transfer by broader literature search combined with real world testing of some degree, the rather large step of conducting new and improved WTP surveys seems to be substantial for improvement of the individual welfare loss estimates.

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Appendix 2. Resource persons

Asthma

Holger Mosbech. Consultant doctor. Allergy Clinic. Rigshospitalet. University of Copenhagen

Contact allergy

Torkil Ménné, Professor and Dr. Jeanne Duus. Department of Dermatology. Gentofte Hospital. University of Copenhagen

Headache

Jes Olesen. Professor of Neurology. Department of Neurology. Glostrup Hospital. University of Copenhagen.

Lung cancer

The estimation of direct costs for lung cancer was based on register data. Therefore a clinical expert was not contacted.

Skin cancer

Krzysztof Drzewiecki. Consultant doctor. Skin cancer clinic. Rigshospitalet. University of Copenhagen.

Appendix 3. Glossary

Benefit transfer	Use of information designed for one specific context to address policy questions in another context
Cycle	Time horizon of the Markov simulation divided into equal increments of time; e.g. one year
DDD	Defined Daily Dose. Based on definition from WHO, the recommended units of medication for one day
Direct costs	Value of medical resources directly related to the treatment
Disease state	Progression of a disease characterised by distinct disease situations (states)
DRG	Diagnosis Related Groups. System used to assign costs to hospital services
Gross production loss	Value of lost production possibilities
GP	General Practitioner
HA	Hospital Ambulatory
ICD-10	International Classification of diseases. 10th revision.
Indirect costs	Value of individual welfare loss and production loss
Markov model	State transition model describing progression of a disease or event
Markov model (Time dependent)	Markov model where the transition probabilities vary over time
MS	Medical Specialist
Net production loss	Value of lost net saving to the economy
Transition probability	Probability of moving from one state to another during a single cycle
Unit cost estimate	Cost per event (e.g. episode of acute headache) or per disease over lifetime (lung cancer)
Utilisation rate	Number of services used within a given time period
VLS	Value of a statistical life
WTP	Willingness to pay