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Cancer Prevent - calculator

Technical report

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Abstract

This technical report describes the methods, data employed and assumptions required for the calculation model Cancer Prevent. The population-based model employs epidemiological methods and data in conjunction with population risk factor prevalence to estimate future disease and related societal costs and health. The model simulations are performed as scenarios, which compare the outcomes between the current risk factor prevalence and another specified prevalence, called the desired situation.

The simulations are based on the adult population prevalence of four lifestyle risk factors: obesity (i.e. BMI>30), daily tobacco smoking, physical inactivity (<2 hours per week) and risky consumption of alcohol (40-60 grams alcohol per day for men and 20-40 grams for women), with the population divided into six age- and gender-specific groups: 18-44 years, 45-64 years and 65-84 years, men and women. The disease risks are taken from international scientific studies and Swedish registers. A total of 13 types of cancers are included.

The societal costs, reported in Swedish krona year 2014 include medical care costs, municipal (local authority) costs for care, and sickness insurance costs, taken from Swedish scientific articles or registers. The costs thus reflect costs for three Swedish sectors; the national social benefit system, the regional healthcare, and the local authorities. To reflect health effects, morbidity is expressed in QALYs and DALYs, based on international scientific reports.

The model is constructed to supply information on potential gains of a successful public health policy for three important stakeholders in Sweden; the national social benefits system, the regional healthcare sector and the local municipal sector Sickness insurance payments are included instead of productivity costs as we believe national-level decision-makers are more interested in costs for the social benefit system. For the same reasons the model contains two different measures of health effects; QALYs and DALYs, as the preferences of decision-makers on health measures differ. We thus believe that the model estimates can supply relevant and valid arguments for decision-makers in the three sectors of Swedish society that have the largest potential to influence the Swedish public health.

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Introduction

The population lifestyle is an important determinant for many common diseases as well as for the future public health. For cancer disease, data on the population lifestyles coupled with epidemiological methods can give relatively certain estimates of future ill-health.

Healthier lifestyles in Sweden are reported to be able to up to 30 per cent of the cancers . Furthermore, the societal costs of the cancer disease burden are considerable; around 3 %
of total health-care expenditure and around 1 % of total Swedish production measured as GDP[1]. These costs are distributed over a wide range of Swedish sectors, e.g. the contribution of the healthcare system only amounts to 35 per cent of the total societal costs. Each year, cancer costs the world more money than any other disease, according to the American Institute of Cancer Research (AICR)
The Swedish National Board of Health and Welfare have issued guidelines on methods to be implemented within the Swedish healthcare to support the population to change four lifestyles: tobacco smoking, risky consumption of alcohol, insufficient physical activity and unhealthy dietary habits. The evidence base for the guidelines included some economic aspects and cost-effectiveness estimates of the methods proposed. The guidelines however indicated that even though the recommended methods are likely to lead to decreases in healthcare costs in the longer term (10-30 years), these cost savings cannot be expected to contribute to the financing of the preventive work during coming years.

We however believe that there is a decision-maker interest in estimates of potential changes in societal costs for cancer diagnoses when population lifestyles change. Epidemiological methods and data in conjunction with population risk factor prevalence can supply prognoses on future disease and ill-health, and related societal costs and health effects can be calculated. These methods, in combination with scenarios on assumed risk factor prevalence, can be used to calculate the probable implications of hypothetical situations. Similar population risk factor models have been reported previously: the Dutch RIVM model[2] , for Australia [3] as well as the OECD & WHO Chronic Disease Prevention (CDP) Model [4].

This report describes the calculation model base on RHS-model (Risk factors, health and societal costs) supported by the Swedish HPH-network. This model has been supplied in digital form (under the name of "Hälsokalkylator") to many Swedish regional healthcare authorities, supported by the same network. This technical report describes the further development and adjustment of RHS-model focusing on cancer diagnoses.

Method and Material

Epidemiological studies report relationships between certain risk factors and certain diseases. Furthermore, there is an epidemiological method that enables calculation of the proportion of a certain disease that would be prevented if the population prevalence of a certain contributing risk factor is decreased (Morgenstern & Bursic, 1982). Based on the prevented cases of disease, changes in future health related societal costs as well as quality of life can be estimated. The epidemiological method thus enables calculations of changes in societal costs and health following from changes in population risk factor prevalence. This section describes the risk factors and related cancer diagnoses included in the Cnacer Prevent-model, all data and assumptions included in the model, and the epidemiological method (called potential impact fraction). The chapter is concluded with a summary of the model input and output data.

The risk factors

The following studies and published data sources were used in the estimations of the related risks for cancer diagnoses and four risk factors: obesity (BMI>30, Daily tobacco smoking, low level of physical activity and risky consumption of alcohol:

- Colditz et al. **Harvard report on cancer prevention volume 4: Harvard Cancer Risk Index**. Risk Index Working Group, Harvard Center for Cancer Prevention, Cancer Causes Control 2000 [5]
- Website Your Disease Risk: http://www.yourdiseaserisk.wustl.edu/CommonPdf/RelativeRisks.pdf
- **Textbook of cancer epidemiology**, Second edition. Editors: Adami, Hunter and Trichpoilos. Oxford University press [6]

Table 1. The risk factors and the cancer diagnoses and ICD-10 disease codes.

	Obesity, BMI>30	Daily smoking	Physical inactivity	Risky consumption of alcohol	ICD-10 code
Breast cancer	x		x		C50
Colorectal cancer	x	x	x		
Colon cancer			x		C18
Rectal cancer			x		C20
Bladder cancer		x	x	x	C67
Kidney cancer	x	x	x	x	C64
Uterine cancer	x	x		x	C54
Cervical cancer		x			C53
Esophageal cancer		x			C15
Adenocarcinoma	*x*				
Squamous carc.*		x	x	x	
Lung cancer		x			C34
Stomach cancer		x	x	x	C16
Liver cancer	x	x			C22
Pancreatic cancer	x	X		x	C25
Laryngeal cancer		x		x	C35

*Squamous carc. = Squamous cell carcinoma

Obesity, BMI>30

Unhealthy dietary habits are one of the most significant modifiable risk factors for several chronic diseases. Based on an ever increasing number of scientific reports, the GBD 2010 describes 14 deficient food habits and reports their contribution to mortality and morbidity. For Sweden three of these (low dietary intake of fruits, of nuts and seeds, and high intake of salt) ranked among the ten most important risk factors for losses of DALYs (GBD 2010 Visualizations;[7]. For the Swedish guidelines for methods to prevent disease a new index on food habits was developed, based on Swedish nutritional recommendations. Unhealthy food habits were defined as low points on the index; 0-4 out of maximum 12 points (Swedish National Board of Health and Welfare, 2011b). However, no epidemiological studies report, yet, disease risks based on the new Swedish dietary index. For all cancer diagnoses the following studies were used to estimate the relative risks for obesity (BMI>30):

Renehan et al**: Body-mass index and incidence of cancer: a systematic review and meta-analysis of prospective observational studies**. *Lancet* 2008, 371:569-578 [8].
Arnold et al: **Global burden of cancer attributable to high body-mass index in 2012: a population-based study.** *Lancet Oncol* 2015, 16:36-46 [9]
Bhaskaran et al: **Body-mass index and risk of 22 specific cancers: a population-based cohort study of 5.24 million UK adults**. *Lancet* 2014, 384:755-765 [10]

For some cancer diagnoses the additional sources are shown in table 2.

Table 2. Relative risks in the model for obesity, BMI>30.

	Women			Men			Additional Sources
	20-44	45-64	65-84	20-44	45-64	65-84	
Breast cancer	0,8	1,2	1,2				
Colorectal cancer							[11]
Colon cancer	1,2	1,2	1,2	1,2	1,2	1,2	
Rectal cancer	1,2	1,2	1,2	1,2	1,2	1,2	
Bladder cancer	1	1	1	1	1	1	
Kidney cancer	1,7	1,7	1,7	1,7	1,7	1,7	
Endometrial cancer	2,5	2,5	2,5				[12]
Cervical cancer	1	1	1				
Esophageal cancer							
Adenocarcinoma	2,2	2,2	2,2	2,2	2,2	2,2	
Squamous cell carcinoma	1	1	1	1	1	1	
Lung cancer	1	1	1	1	1	1	
Stomach cancer	1	1	1	1	1	1	[13]
Liver cancer	1,6	1,6	1,6	1,6	1,6	1,6	[14, 15]
Pancreatic cancer	1,2	1,2	1,2	1,2	1,2	1,2	
Laryngeal cancer	1	1	1	1	1	1	

As the dietary index is not yet used in Swedish population surveys, and nor is most of the GBD 2010 dietary deficiencies, no comprehensive Swedish data exists on the population prevalence of the risk factor. We are thus forced to use the measure BMI (body mass index), which is commonly used in epidemiological studies as a composite measure of food habits in combination with physical activity. Therefore, the model uses obesity, defined as BMI over 30, as an indicator of unhealthy food habits.

See table 1 for the model cancer diseases that are related to a BMI>30, and table 2 for the relative risks for disease.

Daily tobacco smoking

For all cancer diagnoses the following studies were used to estimate the relative risks for daily tobacco smoking:

- IARC monograph volume 100E (2012). **Personal habits and indoor combustions – tobacco smoking**. http://monographs.iarc.fr/ENG/Monographs/vol100E/mono100E.pdf.

- Kuper H, Boffetta P, Adami HO: **Tobacco use and cancer causation: association by tumour type**. *J Intern Med* 2002, 252:206-224 [16]

For some cancer diagnoses the additional sources are shown in table 3.

Smoking tobacco daily increases the risk for premature death and multiply the risks for many cancer diseases; see table 1 for the ones included in the model and table 3 for the relative risks. Tobacco smoking also increases the disease risks for persons that are affected by secondhand smoke, but these risks are not included in the model. Daily tobacco smoking is the definition used in the Swedish guidelines (National Board of Health and Welfare, 2011b).

Table 3. Relative risks in the model for daily tobacco smoking.

	Women			Men			Additional Sources
	20-44	45-64	65-84	20-44	45-64	65-84	
Breast cancer	1	1	1				
Colorectal cancer							
Colon cancer	1,3	1,3	1,3	1,3	1,3	1,3	
Rectal cancer	1,3	1,3	1,3	1,3	1,3	1,3	
Bladder cancer	3	3	3	3	3	3	[17]
Kidney cancer	2	2	2	2	2	2	[18]
Endometrial cancer	0,6	0,6	0,6				
Cervical cancer	1,5	1,5	1,5				[19]
Esophageal cancer							
Adenocarcinoma	3	3	3	3	3	3	
Squamous cell carcinoma	3	3	3	3	3	3	
Lung cancer	10	10	15	10	10	15	
Stomach cancer	1,5	1,5	1,5	1,5	1,5	1,5	[20]
Liver cancer	1,5	1,5	1,5	1,5	1,5	1,5	[21]
Pancreatic cancer	2	2	2	2	2	2	
Laryngeal cancer	10	10	10	10	10	10	

Physical inactivity, < 2 hours/week

Lack of adequate physical activity ranks as the fourth important risk factor for DALY losses in western Europe, as well as in Sweden, in the GBD 2010 (Lim et al, 2012), and most population groups in Sweden would benefit from an increased physical activity. In the model physical inactivity is defined as less than 2 hours physical activity per week. That definition is somewhat different from the definition in the Swedish guidelines: less than 150 minutes per week at a moderate level or less than 75 minutes per week at a high intensity level (Swedish National Board of Health and Welfare, 2011b). Table 1 reports the cancer diseases related to physical inactivity and table 4 the relative risks.

For all cancer diagnoses the following studies were used to estimate the relative risks for physical inactivity:
Friedenreich et al, 2010[22],
Physical Activity Guidelenes Advisory Committee Report, 2008, http://health.gov/paguidelines/report/

Schmid et al, 2014 [23]

For some cancer diagnoses the additional sources are shown in table 4.

Table 4. Relative risks in the model for physical inactivity, <2 hour/week.

	Women			Men			Additional Sources
	20-44	45-64	65-84	20-44	45-64	65-84	
Breast cancer	1,2	1,2	1,2				[24]
Colorectal cancer							
Colon cancer	1,5	1,5	1,5	1,5	1,5	1,5	
Rectal cancer	1	1	1	1	1	1	
Bladder cancer	1	1	1	1	1	1	[25]
Kidney cancer	1	1	1	1	1	1	
Endometrial cancer	1,3	1,3	1,3				[26]
Cervical cancer	1	1	1	1	1	1	
Esophageal cancer							
Adenocarcinoma	1	1	1	1	1	1	
Squamous cell carcinoma	1	1	1	1	1	1	
Lung cancer	1	1	1	1	1	1	
Stomach cancer	1	1	1	1	1	1	[27]
Liver cancer	1	1	1	1	1	1	
Pancreatic cancer	1	1	1	1	1	1	
Laryngeal cancer	1	1	1	1	1	1	

Risky consumption of alcohol

High consumption of alcohol increases the risks for premature death 3-7 times [28] and it ranks as the eights risk factor for DALY losses in Western Europe in the GBD 2010 [7] (Lim et al, 2012). Excessive alcohol consumption is related to a large number of diseases [29]

For all cancer diagnoses the following studies were used to estimate the relative risks for risky consumption of alcohol**:** IARC monograph volume 100E (2012), http://monographs.iarc.fr/ENG/Monographs/vol100E/mono100E-11.pdf

Bagnardi et al, 2015[30]

Table 5. Relative risks in the model for risky consumption of alcohol.

	Women			Men			Additional Sources
	20-44	45-64	65-84	20-44	45-64	65-84	
Breast cancer	1,3	1,3	1,3				
Colorectal cancer							
Colon cancer	1,4	1,4	1,4	1,4	1,4	1,4	
Rectal cancer	1,4	1,4	1,4	1,4	1,4	1,4	
Bladder cancer	1	1	1	1	1	1	
Kidney cancer	1	1	1	1	1	1	
Endometrial cancer	1	1	1	1	1	1	
Cervical cancer	1	1	1	1	1	1	
Esophageal cancer							
Adenocarcinoma	1	1	1	1	1	1	

Squamous cell carcinoma	2	2	2	2	2	2	
Lung cancer	1	1	1	1	1	1	
Stomach cancer	1	1	1	1	1	1	
Liver cancer	1,1	1,1	1,1	1,1	1,1	1,1	[31]
Pancreatic cancer	1,1	1,1	1,1	1,1	1,1	1,1	
Laryngeal cancer	1,1	1,1	1,1	1,1	1,1	1,1	

For some cancer diagnoses the additional sources are shown in table 5.

Unfortunately, there exist several definitions of excessive alcohol consumption. Hazardous consumption of alcohol in Swedish population surveys is normally defined based on the so-called AUDIT index (8 and more points for men and 6 and more for women) [32]In the Swedish guidelines, the term risky consumption of alcohol is used, defined as a weekly consumption exceeding 14 standard units for men and 9 for women (one standard unit contains 12 grams of pure alcohol; thus equivalent to 24 grams per day for men and 15 grams for women, respectively) or binge drinking at least once a month (5 or more standard units for men and 4 or more for women on the same one occasion. The Swedish Costs of Alcohol study (i.e. Johansson et al, 2006 in table 5) define hazardous alcohol consumption as 40-60 grams alcohol per day for men and 20-40 grams for women[33]

The model diseases

The model includes 13 types of cancer diagnoses, which epidemiological studies have related to the four lifestyle risk factors.

Table 6. Annual incidence in the model diseases in Sweden, per 100 000. (SoS, Cancer Register, 2013)

	Women			Men		
	18-44	45-64	64-84	18-44	45-64	64-84
Breast cancer	51.81	313.78	463.13			
Colorectal cancer						
Colon cancer	4.62	32.81	162.55	4.06	32.84	177.39
Rectal cancer	1.76	21.1	64.43	2.25	30.08	104.43
Bladder cancer	0.52	10.97	47.63	1.69	29.49	189.82
Kidney cancer	1.04	9.97	43.11	3.06	22.96	64.11
Endometrial cancer	1.69	31.4	98.13			
Cervical cancer	14.11	10.88	11.79			
Esophageal cancer						
Adenocarcinoma	0	0.58	3.81	0.19	5.15	18.11
Squamous cell carcinoma	0.13	1.25	4.88	0	2.37	10.97
Lung cancer	1.5	38.96	154.69	1.37	33.9	186.11
Stomach cancer	0.98	5.32	22.15	0.75	10.7	46.13
Liver cancer	0.2	11.13	47.87	1	12.01	32.78
Pancreatic cancer	0.65	11.13	47.87	0.5	13.23	50.63
Laryngeal cancer	0	0.5	1.55	0.12	3.27	11.5

These diagnoses constitute around 45 % of the Swedish cancer incidence (SoS, Cancer Register, 2014). Table 6 reports the annual incidence in the diseases in the Swedish population.

The disease costs

To each of the 13 model diseases, societal costs are assigned. The costs include medical care costs, municipal (local authority) costs for care, and sickness insurance costs. The costs thus reflect costs for three Swedish sectors; the national social insurance, the regional healthcare, and the local authorities. The costs should be interpreted as annual costs per person, reported in Swedish SEK year 2014 .

Medical care costs

The medical care costs are taken from Swedish national and regional registers on healthcare consumption. All costs are average annual disease-specific costs for hospital inpatient, specialist outpatient, and primary health care per person over the genders and age-groups., see table 7

Table 7. Medical care costs, annual per person, in SEK year 2012.

	Annual cost	Source
Breast cancer	41 700	Stockholm county council register ,Swedish national register, KPP
Colorectal cancer	125 000	Stockholm county council register ,Swedish national register, KPP
Bladder cancer	150 000	Stockholm county council register ,Swedish national register, KPP
Kidney cancer	149 000	Stockholm county council register ,Swedish national register, KPP
Endometrial cancer	52 000	Stockholm county council register ,Swedish national register, KPP
Cervical cancer	65 000	Stockholm county council register ,Swedish national register, KPP
Esophageal cancer	95 000	Stockholm county council register ,Swedish national register, KPP
Lung cancer	72 500	Stockholm county council register ,Swedish national register, KPP
Stomach cancer	60 500	Stockholm county council register ,Swedish national register, KPP
Liver cancer	64 000	Stockholm county council register ,Swedish national register, KPP
Pancreatic cancer	56 200	Stockholm county council register ,Swedish national register, KPP
Laryngeal cancer	130 000	Stockholm county council register ,Swedish national register, KPP

The Stockholm county council medical consumption register, set up to enable internal market transactions within the county council, covers all medical care for all Stockholm county inhabitants (2.1 million in 2012) since the year 1997. Each healthcare episode of each inhabitant is recorded, with up to 10 diagnoses, under a personal identification number. The register thus enables the calculation of disease-specific medical costs per individual during a series of years. The inpatient and outpatient consumption are priced according to the Stockholm county council NordDRG-based pricelist, while primary care is valued by Swedish standard costs.

The costs for the present study were calculated by dividing the disease-specific alcohol-attributable cost by the number of alcohol-related cases. Note that this does not imply costs per individual but costs per case. To the extent that the same individual might constitute several cases during a certain year, the costs are underestimated.

Municipal costs for care

Data on disease-specific costs accrued by the municipals (local authorities) for community services in Sweden are very sparse. In the model we thus use a novel approach, relating the model diseases to certain levels of need of community services, enabled by a publication that reports costs based on functional levels [34]. Municipal community services are approved based on needs for support in daily activities, not because of specific diseases. We thus propose that municipal care costs described from functional level can be used to estimate expected costs of services for certain diseases, if the typical need of community services because of these diseases also is described by functional level.

Table 8. Municipal care costs, annual per person, in SEK year 2014, and assumed IADL class.

	Annual cost	IADL dependencies
Cancers:	95 000	2-4

Source: Lindholm et al, 2013. Estimated from figures 1 and 2.

The model diseases were classified into number of IADL dependencies (Instrumental Activities of Daily Living; seven possible dependencies including shopping for groceries, cooking, cleaning, doing laundry, taking care of one's finances, using the telephone, and using public transportation) based on the lay descriptions of disease used for the GBD 2010 [35]. The municipal care costs, including accommodation, home help, and home health care, for the IADL classes were then approximated from [34]. Note that the costs could be somewhat overestimated, as they were calculated for an elderly (aged 65+) cohort, even though age *per se* does not constitute a reason for approved community services in Sweden.

Sickness insurance costs

The sickness insurance costs included in the model are costs to the national social security system because of disease, constituting a transfer to substitute lost income because of sickness. Note that the costs are not the so-called productivity costs, recommended to be included in Swedish health economic evaluations [36, 37], but reflects the costs of disease for the national level sector in Sweden.

Table 9. Sickness insurance costs, annual per person, in SEK year 2014.

	Paid days for sickness absence	80 % of average salary (day)	Annual costs
Cancers:	222	1 427	253 483

Source: https://www.forsakringskassan.se/statistik/

The costs are calculated based on estimated level of sickness absence, based on the official statistics from State Insurance (Försäkringskassan). The social security benefit level was assumed to 80% of lost income, where the lost income is based on the average salary in Sweden in year 2014; 31 400 SEK per month.

Disease health effects

The health effects because of disease are described in the model as the decreased number of incident cases of disease and as two separate measures of health; increased health-related quality of life (QALYs) and decreases in disability (DALYs).

Quality-adjusted life-years (QALYs)

The QALY weights are used to describe the losses in health-related quality of life due to the model diseases, see table 10. The weights are community-based, derived via the EQ-5D classification system with the UK time-trade-off valuations [38] The weights are applied to a year lived with disease for all ages and genders, thus not taking into account the decreased average quality of life in older ages and the differences in average quality of life between the genders [39]The QALYs are calculated as increases in health, i.e. as the difference to full health (with a weight of 1).

Disability-adjusted life-years (DALYs)

The DALY weights are used to describe the disability due to the model diseases, see table 10. The weights are taken from the new Global Burden of Disease reports, the GBD 2010 [35]. The weights are applied to a year lived with disease for all ages. The DALYs are calculated as losses of full health (with a weight of 1).

Table 10. QALY and DALY weights, for a year spent in disease.

	QALY weight	DALY weight

Breast cancer	0.76	0.29
Colorectal cancer	0.67	
Bladder cancer	0.71	
Kidney cancer	0.69	
Endometrial cancer	0.56	
Cervical cancer	0.76	
Esophageal cancer	0.82	
Lung cancer	0.56	
Stomach cancer	0.67	
Liver cancer	0.67	
Pancreatic cancer	0.67	
Laryngeal cancer	0.76	

Source: Sullivan et al, Salomon et al.

Epidemiological data and methods

The RHS-model is population-based, linking the population prevalence of risk factors to future disease incidence via the risks for disease and the current disease incidence, for each modeled disease. Changes in population risk factor prevalence is assumed to lead to changes in future incidence, calculated by the epidemiological method called potential impact fraction, that estimates the fraction of the current disease incidence that could be prevented in the future. This section describes the model epidemiological data and assumptions; the population groups considered, the choices and format of the risk equation.

Population groups

The model covers the adult population, divided into six age- and gender-specific groups; age groups 20-44 years, 45-64 years and 65-84 years, and men and women. The age groups are chosen to correspond to common age groups in Swedish population surveys, to reflect differing disease risks and disease patterns, and to take account of the Swedish institutional setting.

Only the adult population is included, as the risk factors affect disease mainly in adult years. Disease is however comparatively rare at the younger ages, see table 6. The middle age group 45-64 years is chosen mainly to be able to correctly model the sickness insurance costs, as the Swedish customary age of retirement from work is around 65 years. The oldest included age is 84 years, as the very high disease prevalence among the elderly makes it more difficult to establish causality between risk factors and disease incidence, leading to a lack of epidemiological data. The gender division is necessary as there are marked differences in risk factor prevalence as well as in disease risks between men and women.

The risk factor prevalence in the model population groups can be found in customary Swedish population surveys, that periodically study the lifestyles of the Swedish population, at national as well as regional level.

The disease incidence

The future disease incidence in the model results is based on the current disease incidence rate, age group- and gender-specific, see table 6. The model takes advantage of the unique breadth and width of Swedish national and local registers, foremost the databases from Swedish National Board of Health and Welfare (SoS, Socialstyrelsen). The data were taken from the Cancer register, where yearly incidence is regularly updated and presented separately for genders and age. Average incidence rates for 2012 for the population groups included in the model were calculated.

Studies report differential disease patterns in Swedish regions [40], but as this might be due to differential risk factor patterns, the model uses the Swedish national average disease rates. The incidence rate is reported as incident cases of disease per 10,000 person-years. Together with the number of inhabitants in the population groups, the incidence rate is employed to calculate the number of incident cases in the population studied.

The risk equation

The starting points of the simulations are the increased risk for disease for a person with a certain risk factor, compared to the risk of a person without the risk factor. This risk is often called the relative risk [41], [42] (Morgenstern & Bursic, 1982; Kleinbaum et al, 1982) which is defined formally as: the risk of disease in relation to exposure of a risk factor. The relative risk is calculated, for each disease, as the risk of an outcome (i.e. an incident case of disease in our model) in the exposed group (i.e. among people with the risk factor) divided by the risk in the unexposed group (i.e. among people without the risk factor). The relative risk is thus the extra risk that is related to a certain risk factor.

The relative risks in the model are reported in tables 2 to 5, for each respective risk factor, for the six population groups. We selected those studies which presented relations between the risk factor and the probability to contract a disease in terms of a relative risk. If relative risks were not available, they were calculated based on the reported data from long-term epidemiological studies. One of the important factors in choosing the specific study was the possibility to obtain data distributed according to gender and age. If no retrieved study reported such data, we assumed that the relative risks reported were the same for men and women independent of age.

The age group- and gender-specific relative risks together with the risk factor prevalence in the population group are used to calculate the potential impact fraction, often called IF. The IF is the proportion of the current disease incidence that could be prevented in the future if the risk factor prevalence is changed, see equation below.

Potential impact fraction

$$IF = \frac{[(p2 - p1) + RR(p1 - p2)]}{[(1 - p1) + RR * p1]}$$

p1 is the prevalence of the risk factor in the population group at present
p2 is the changed prevalence of the risk factor in the population group
RR is the relative risk

Summary of model input and output data

The model thus contains several types of data, often called parameters in modelling. These can be divided into fixed parameters and input parameters. The fixed parameters are derived from scientific studies or registers and should in most cases be kept unchanged when running the model. The input parameters describe the scenarios that are to be modelled.

The fixed parameters are:

- Relative risks for the 13 cancer diagnoses, subject to the risk factor prevalence, for the six gender-specific age groups (tables 2- 5)
- Incidence in the 13 cancer diagnoses, for the six gender-specific age groups (table 1)
- Annual societal costs for a person with a certain disease (tables 7-9)
- Annual health effects, in QALYs or DALYs, for a person with a certain disease (table 10)

The input parameters are:

- Number of population , for the four gender-specific age groups
- Current prevalence of the four risk factors in the six gender-specific age groups, expressed in decimals (i.e. 0.12 instead of 12%)

- Desired prevalence of the four risk factors in the six gender-specific age groups, expressed in decimals (i.e. 0.1 instead of 10%)

Based on the fixed parameters and the chosen input parameters, the model calculates a result, i.e. an output.

The model outputs show:

- Changes in number of incident cases
- Changes in societal costs, total as well as per sector
- Changes in health effects, in QALYs and DALYs

Discussion

This technical report describes the methods and data employed and assumptions required for the simulation model RHS (Risk factors, health and societal costs), applied for the cancer diagnoses. The model describes the effects of changes in the population prevalence of four common lifestyle risk factors for disease in terms of disease incidence and related societal costs and health effects. The simulations use epidemiological data and methods in conjunction with health economic data on disease costs for three Swedish sectors of society and two different measures of health, to enable a comprehensive description of the potential effects of public health measures.

The model contains several assumptions and rather crude averages, which imply that the results from the scenarios should be regarded as mere simulations, or rough estimates, of the effects of successful prevention work. The model however contains the most relevant risk factors for disease in Sweden, according to the GBD 2010 [7 and there are prevention measures that can affect these risk factors, according to the guidelines from the Swedish National Board of Health and Welfare (Socialstyrelsen). The epidemiological method is similar to the one used for the GBD 2010 [Lim, 2012 #4608]and the disease risk are taken from renowned international scientific studies, while Swedish registers on disease incidence and healthcare patterns coupled with regional population surveys have been used whenever possible in order to reflect Swedish and regional circumstances.

The most significant uncertainty of data validity is probably found in the model estimates for the municipal care costs and the sickness insurance costs, as the lack of data forced us to resort to crude assumptions (maybe best denominated as “guess estimates”) on the disease-specific costs. The lack of disease-specific costs for the two sectors of society is well-known in Sweden, and as the overall objectives of the two sectors is focused on functional disabilities rather than specific diseases it is implausible that comprehensive data on disease-specific costs will be collated in the near future. The methodology employed here, to convert diseases into functional disabilities, might thus be the most tractable way to enable inclusion of costs for these two important Swedish sectors.

The model aim is not to calculate future disease incidence and related costs for the Swedish population, but merely to calculate the implications of minor changes in the prevalence of some risk factors for disease. A more comprehensive, and complex, model would include more risk factors as well as mortality and morbidity patterns for a wide range of diseases. It is of course not possible to avoid all diseases, and deaths, -every person contracts disease and die, eventually. The model does not include any of these dynamic effects, often called competing risks within epidemiology, that imply that decreases in the incidence for one disease leads to increases in other diseases instead. This substitution disease of course implies costs and ill-health. Furthermore, the model does not include mortality.

Partly due to these reasons, we recommend that the model results are reported as changes, in the number of diseased persons, in health and in societal costs. The modelling however is performed as estimates of the risk factor effects on the total number of diseased persons, on the total societal costs and on the numbers of QALYs and DALYs. Many other factors affect the future situation, apart from the prevalence of the four risk factors, such as changes in the demographic structure, changes in medical technology and practice, changes in other risk factors for disease, and changes in other environmental and societal circumstances. We thus strongly recommend that the model results are interpreted in a restrictive manner –in terms of changes following minor changes in population risk factor prevalence under the (unrealistic) assumption that everything else remains identical.

The results do not sum the number of cases avoided, the increased health nor the decreased costs over the risk factors. The reason is that there is a strong correlation between two of the risk factors; obesity and physical inactivity. These are often concurrent in individuals, preventive primary care work often addresses the two risk factors simultaneously and the disease patterns are similar. In fact, physical inactivity could be regarded a risk factor for obesity. On individual-level the risk for overestimates is obvious; a person that increases the physical activity and thus decrease his/her BMI can only avoid one case of the disease. Albeit to a lesser extent, this overestimate can occur also on population-level. But, the risks might also be multiplicative, so that a person with several risk factors might run a higher risk of contracting disease, which is not included in the estimates. It is unclear how the two aspects are related; do they lead to under- or overestimates? In order to present conservative estimates, we recommend not to sum the effects of the risk factors, in contrast to the GBD 2010.

The model generates relevant data for several Swedish sectors of society; the national social benefits system, the regional healthcare sector and the local municipal sector, that we think are important stakeholders for the Swedish public health. Instead of productivity costs, i.e. the loss of societal resources due to individuals´ inability to engage in remunerated work, the model includes the payments of sickness insurance that cover individuals´ loss of income due to sickness, i.e. transfer payments. The reason is that the model is constructed to supply information on potential gains for public health stakeholders, and we believe that potential decreases in sickness insurance costs are relevant arguments for Swedish national level decision-maker. For the same reasons the model contains two different measures of health effects; QALYs and DALYs, as the preferences of decision-makers on health measures differ. We thus believe that the model estimates can supply relevant and valid arguments for decision-makers in the three sectors of Swedish society that have the largest potentials to influence the Swedish population health.

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