Folkhälsomyndigheten
PUBLIC HEALTH AGENCY OF SWEDEN

NCDSim – A Simulation Model for the Future Development of Non-Communicable Diseases

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Abbreviations

ATC	Anatomical Therapeutic Chemical
CVD	Cardiovascular Disease
ICD	International Classification of Diseases
IHE	Institute for Health Economics
PAF	Population Attributable Fraction
RTB	Total Population Register
SCB	Statistics Sweden

Background

The Swedish Public Health Agency, in collaboration with the Swedish Cancer Society and the Heart-Lung Foundation, has developed a simulation tool—NCDSim—with a web-based user interface. This tool enables the study of future trends in cancer and cardiovascular diseases and the potential impact of interventions targeting major risk factors.

NCDSim is based on Statistics Sweden's (SCB's) population projections and can illustrate the potential development of these diseases up to the year 2120. For many purposes, shorter-term projections are sufficient.

A key principle of the project is that NCDSim is based on the best available empirical data regarding population composition, risk factor prevalence, and disease incidence. Estimates are derived from data provided by SCB, the National Board of Health and Welfare, the Swedish Public Health Agency, and the Swedish Food Agency. Relative risks for disease incidence, based on the presence of risk factors included in the model, have been sourced from the academic literature.

Purpose

NCDSim is designed to support exploratory analyses, allowing assumptions to be easily modified in order to create different scenarios for future development. Typical questions that can be addressed using scenario simulations include how preventive measures, targeting one or more of the risk factors included in the model, might influence the future development of these diseases. One application of the model is to provide a basis for assessing whether various goals, such as those outlined in Agenda 2030, are achievable—or, if not, what types of measures would be required to make them so.

Currently, NCDSim is being used to analyse the development of cancer and cardiovascular disease, but it can be adapted for other non-communicable diseases for which historical data on prevalence and incidence are available or for which similar assumptions can be made.

NCDSim provides annual results on the number of ongoing cases, new cases, deaths, and healthcare costs for the diseases in question. The results are presented clearly in the model's web interface and can also be exported for further analysis using other software.

Method

Structure and Content of NCDSim

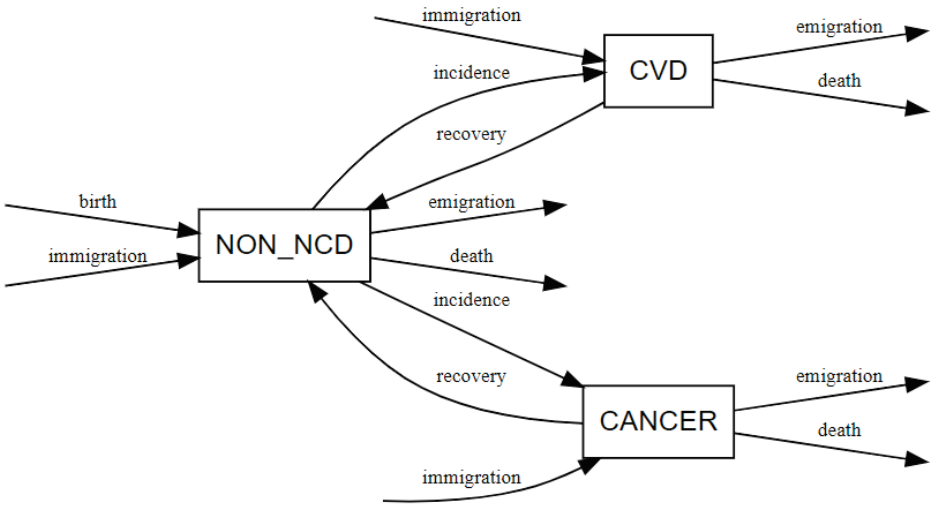
NCDSim is a system dynamics model, meaning it handles stocks and flows. Stocks refer to the number of individuals sharing common characteristics at a given time, such as those with a specific disease. Stocks can also be referred to as compartments or states. Flows refer to the number of individuals moving between two stocks, or changing states, over a specific time interval. Examples of flows in NCDSim include the number of individuals who fall ill with a particular disease or who recover from it in a given year.

While stocks represent counts at a specific point in time, flows represent a rate of change or intensity over a time interval. In NCDSim, the model is simulated in annual time steps. Stocks refer to the number of individuals in each state as of December 31 of each year, while flows refer to the number of individuals moving between stocks during the same calendar year.

NCDSim does not represent individuals, but instead represents groups of individuals. All individuals within a stock share identical characteristics, and the only relevant information is the number of individuals in the stock. Similarly, flows between stocks are entirely homogeneous.

Figure 1 shows a stock-flow diagram in NCDSim. The model has three stocks (the boxes in the figure), namely individuals with cancer, individuals with cardiovascular disease, and individuals without either disease. The 14 flows (arrows in the figure) include demographic events (births, deaths, immigration, and emigration) and epidemiological events (incidence and recovery).

Figure 1 - Stocks/flows diagram for NCDSim



An important aspect of NCDSim is its ability to realistically simulate future demographic developments. The increasing proportion of the elderly in the population, according to SCB's projections, is expected to significantly impact the

disease burden. Therefore, NCDSim is designed with separate modelling for each of the 202 combinations of sex and age. Age is represented in one-year classes from 0 to 99, with an open-ended age group for 100 and older. This means the model contains 202 sets of stocks and flows, which can be viewed as each stock and flow containing 202 cells for storing sex-specific and age-specific counts. Most assumptions, such as risk factor prevalence, are also made by sex and age.

After the model simulates changes in stocks and corresponding flows over a calendar year, the population frequency in each of the 202 cells is moved to the cell representing the next higher age within each stock. However, in the cell for individuals aged 100 and older, frequencies for surviving individuals accumulate.

The model's flows are mathematically described as the product of a risk population and an intensity rate. The risk population formally refers to the risk time generated in a population, such as person-years. The intensity rate refers to the number of events per unit of time, such as the number of deaths per person-year. Intensity rates are estimated by dividing the number of events (e.g., demographic changes) by the risk time generated in a specific sex and age category. For demographic flows, good agreement with SCB's population projections is achieved by calculating the intensity rates from the projected population and its demographic components.

To ensure that NCDSim simulates a realistic development of disease trends, it is crucial to account for differences in mortality by sex and age between stocks with and without disease. Separate death risks have therefore been estimated from SCB and National Board of Health and Welfare data for each stock and are used in the simulation.

Flows related to disease incidence are calculated by multiplying the risk time in each sex and age category among the non-diseased by a factor proportional to the total attributable fraction for the incidence in each non-communicable disease. This method is described in more detail below.

Flows related to recovery are based on estimates of average disease duration. Separate estimates are made for cancer and cardiovascular disease.

NCDSim is implemented in the R programming language, and the graphical user interface is implemented using the R package Shiny.

Data Sources and Definitions

The definitions of cancer and cardiovascular disease used in NCDSim largely follow those used by Freisling et al. (2020), which served as the primary source of information during the initial phase of model development. Both disease categories include a relatively large number of individual diagnoses and are therefore somewhat heterogeneous from a clinical perspective and in terms of incidence, prevalence, disease duration, and mortality. NCDSim simulates the expected development for these diagnostic groups as a whole, not for individual diagnoses

within the group. An implicit assumption is that the composition of diagnoses within the groups remains constant over time.

The estimates of prevalence, incidence, and death risks that are used as input in NCDSim are based on individual data from SCB (the Total Population Register) and the National Board of Health and Welfare (patient registers for inpatient and specialised outpatient care as well as the cancer register). In these calculations, NCDSim's stocks—i.e., the number of prevalent disease cases for each historical year—are defined as follows:

1. Cancer patient stock: The number of individuals with at least one registered malignant primary tumour (ICD-10 codes C00-C97, D00-D09) in the cancer register during the year or in any of the previous four years.
2. Cardiovascular disease patient stock: The number of individuals with at least one healthcare visit registered in the patient register with a main or secondary diagnosis for any of the ICD-10 codes B33, F01, I01-I09, I20-I26, I27, or I28-I73 during the year or in any of the previous four years.
3. Stock of individuals without cancer or cardiovascular disease: The difference between the total number of individuals in the population, according to SCB's Total Population Register, and the sum of 1 and 2.

Note that stocks are defined based on a five-year period prevalence, with the method differing between diseases depending on the data sources used. The method for defining an incident case also differs for the same reason.

For cancer calculations, information on newly registered malignant tumours from the cancer register is used. An individual with at least one registered malignant primary tumour in a year is defined as an incident case. An individual is defined as a prevalent case during the year of incidence and for the following four years. If a new malignant primary tumour is registered during the prevalence period, which is relatively rare, the period restarts without the individual being considered an incident case again.

For cardiovascular disease, data on healthcare visits and diagnosis codes from the patient register are used. An individual is defined as a prevalent case if they have had at least one healthcare visit with a relevant ICD code during the current year or any of the previous four years. If an individual is not a prevalent case, they are at risk for incidence, meaning they are counted as an incident case if there is at least one healthcare visit during the year. Note that the individual is simultaneously defined as a prevalent case.

It should be noted that, based on the above definitions, individuals may have uninterrupted five-year prevalence periods, or time in the disease state, lasting longer than five years. For example, an individual who has a healthcare visit every fourth year over a longer period will be counted as an incident case only at the first visit and thereafter as a prevalent case up to and including four years after the last visit, regardless of how much time has passed since the individual was an incident case. Longer periods of disease duration are much more common in cardiovascular

disease than in cancer. Because individual data for long periods are required in order to make reliable estimates of the average disease duration, these have instead been estimated indirectly through simulation.

In calculating the stocks, stocks 1 and 2 are treated independently, meaning that the same individual can be marked as both a cancer patient and a cardiovascular patient. However, the model currently does not allow for comorbidity, which leads to a slight overestimation of the number of individuals with cancer or cardiovascular disease and a corresponding underestimation of the number without disease. Healthcare costs are assumed to be correct, provided that the cost of care for a patient with comorbidity is comparable to that for a patient without comorbidity. Because the focus of the simulations has been to analyse cost development, the overestimation of disease prevalence is considered acceptable. The degree of comorbidity for cancer and cardiovascular disease is also relatively limited, and only about 10% of all individuals with disease suffer from both diseases. However, this proportion increases with age, reaching nearly 20% in the 90+ age group.

Definition and Prevalence of Risk Factors

The prevalence of the various risk factors included in NCDSim has been estimated from two data sources, namely the Swedish Public Health Agency's National Public Health Survey Health on Equal Terms? (Hälsa på lika villkor?, HLV) for non-dietary risk factors and the Swedish Food Agency's Riksmaten survey for dietary risk factors. The estimates have, as far as possible, taken into account differences between sexes and ages. Risk groups are not represented by explicit stocks in NCDSim but are calculated as proportions of the population without cancer or cardiovascular disease and who are therefore at risk for disease incidence. Risk factors are considered to be independent from each other, and the calculation of risk group sizes can therefore be performed separately for each risk factor. Based on each risk factor, the population without disease is dichotomised into a group with increased risk (relative risk greater than one) and a reference group (relative risk equal to one). The thresholds for dichotomisation are shown in Table 1.

For dietary risk factors, thresholds have been chosen, as far as possible, to align with the Nordic Nutrition Recommendations. Where possible, the thresholds for dichotomisation of non-dietary risk factors have been selected to match the definitions in the studies where the relative risk was estimated. In cases where it has not been possible to use the same definitions, an adjustment of the relative risk has been made so that they are consistent with the dichotomisation used in NCDSim.

Table 1 - Average prevalence of risk factors (proportions) in people aged 16–85

Risk Factor	Men	Women	Source	Threshold
Fruit intake	0.83	0.71	Riksmaten	< 200 g/day
Whole grains	0.89	0.94	Riksmaten	< 100 g/day
Vegetables	0.84	0.78	Riksmaten	< 200 g/day
Meat (red and processed)	0.81	0.66	Riksmaten	50 g/day
Salt	0.85	0.62	Riksmaten	6 g/day
Obesity	0.17	0.17	HLV	BMI > 30
Smoking	0.05	0.06	HLV	Daily smoker
Insufficient physical activity	0.31	0.30	HLV	< 150 min/week of pulse-raising activity
Alcohol consumption	0.20	0.10	HLV	> 12 g/day

Some disease cases cannot be attributed to the risk factors included in the model and are instead due to chance, genetic risk factors, or other risk factors not included in the model. The total attributable fractions for cancer and cardiovascular disease were estimated from reports produced by the Institute for Health Economics (IHE) on behalf of the Swedish Cancer Society and the Heart-Lung Foundation. After adjusting the attributable fractions reported in the studies—considering differences between the diagnosis codes included in the studies and those in NCDSim—the total attributable fraction for the included risk factors was 18% for cancer and 39% for cardiovascular disease. This means that NCDSim assumes that 18% of all cancer cases and 39% of all cardiovascular disease cases can be attributed to lifestyle factors. Conversely, it is assumed that 82% of all cancer cases and 61% of all cardiovascular disease cases cannot be attributed to lifestyle factors.

Relative risks for disease incidence

NCDSim uses relative risks in the presence of risk factors to simulate disease incidence. The methodology is described in more detail in the next section. Relative risks have been sourced from articles published in scientific journals. Table 2 presents the risk factors included in the model, along with information on the diagnosis codes within each disease category that form the basis for the risk estimates and the studies used as sources.

Table 2 - Risk factors, specific diagnosis codes (ICD-10), literature references, and relative risks (RR) for cancer and cardiovascular disease (CVD)

Risk factor	Disease (ICD-code)	Source	RR cancer	RR CVD
Fruit intake	Cancer (C15, C33-C34), CVD (I20-I25, I60-I63)	GBD 2019 (2020)	1.004	1.029
Vegetables	Cancer (C15), CVD (I20-I25, I60-I63)	GBD 2019 (2020)	1.0	1.024
Whole grains	Cancer (C15, C33-C34), CVD (I20-I25, I60)	GBD 2019 (2020)	1.012	1.063
Meat (red and processed)	Cancer (C50, C18-C20), CVD (I20-I25, I60-I63)	GBD 2019 (2020)	1.021	1.078
Salt	CVD (B33, F01, I01-I09, I20-I26, I27, I28-I73)	Yi-Jie Wang et al. (2020)	1.0	1.15
Smoking	Cancer (C00-D09), CVD (B33, F01, I01-I09, I20-I26, I27, I28-I73)	Freisling et al. (2020)	1.37	2.15
Insufficient physical activity	Cancer (C00-D09), CVD (F01, I01-09, I20-I79)	Garcia L. et al. (2023)	1.09	1.25
Obesity (BMI)	Cancer (C00-D09), CVD (B33, F01, I01-I09, I20-I26, I27, I28-I73)	Freisling et al. (2020)	1.056	1.374
Alcohol consumption	Cancer (C00-C15,C18-C20,C22,C32-C33), CVD (I48)	Carr et al. (2024); Bauer et al. (2024); 403: 2162–203, Lankester et al. (2021)	1.042	1.046

For some risk factors, relative risks are not reported for all diagnoses included in the cancer and cardiovascular disease categories as defined in NCDSim and are only reported for a subset of diagnosis codes. This applies to several dietary risk factors and to insufficient physical activity. In these cases, the relative risks have been weighted against the proportion of total disease prevalence within each disease category represented by the relevant diagnosis codes.

For several risk factors, the relative risks in the studies were estimated using a different categorisation than that used in NCDSim. In some cases, more than two categories were used, or dichotomisation was performed at a different threshold. In some cases, hazard ratios were estimated with the risk factor as a continuous variable. In all cases, a recalculation of the estimated relative risks was performed to make it possible to apply the relative risks to NCDSim's dichotomous risk groups.

After the adjustments described above, relative risks for each risk factor and disease group are obtained, which can be used to simulate disease incidence according to the method described in the next section.

Simulation of incidence based on attributable fractions

The total contribution to the risk of disease incidence attributable to a risk factor depends on both the prevalence of the risk factor and the increase in risk given its presence. In NCDSim, the concept of the attributable fraction (the population attributable fraction, PAF) is used to quantify the contribution of risk factors to

disease incidence. For each risk factor, an attributable fraction is calculated, representing the risk factor's contribution to total disease incidence.

Populations with a risk factor prevalence are not represented by explicit stocks in the model but are calculated as a proportion of the stock without disease. In the following formal description, *J* denotes the number of risk factors with prevalence $p_{s,a}^{j}$ for risk factor *j*, sex *s*, and age a. For each risk factor, the stock of individuals without disease can be divided into two groups, namely individuals with increased risk of disease incidence and a reference group.

For both cancer and cardiovascular disease, the relative risk for each risk factor is assumed to be independent of sex and age and is denoted by RR^{j}. The contribution to total incidence, or PAF, for risk factor *j*, sex *s*, and age a is calculated as:

$$PAF_{s,a}^{j} = \frac{p_{s,a}^{j}\left(RR^{j} - 1\right)}{1 + p_{s.a}^{j}(RR^{j} - 1)}$$

$$CPAF_{s,a} = 1 - \left(1 - w_1 PAF_{s,a}^{1}\right)\left(1 - w_2 PAF_{s,a}^{2}\right) \ldots \left(1 - w_J PAF_{s,a}^{J}\right)$$

The total incidence contribution, or combined attributable fraction, from the risk factors included in NCDSim for sex *s* and age a, denoted $CPAF_{s,a}$, is calculated as:

where $w_j = 1 - C_j$. The so-called communality C_j for the *j*th risk factor refers to the degree of overlap, or covariation, with other risk factors. The higher the degree of overlap, the more $PAF_{s,a}^{j}$ needs to be reduced to avoid overestimation of $CPAF_{s,a}$. Estimating C_j requires data on all risk factor prevalences $p_{s,a}^{j}$, see, for example, Norton et al. (2014). Because not all risk factors were observed in the same dataset, reliable estimates of C_j could not be made. Therefore, in the current version of the model independence between risk factors is assumed, i.e., $w_j = 1$.

It should be noted that the definition of $CPAF_{s,a}$ implies that the weighting of attributable fractions is done multiplicatively, thus ensuring that the combined attributable fraction is always less than one. This also means that the total attributable fraction cannot be expressed as a sum of the individual risk factors' contributions.

Attributable fractions and combined attributable fractions are calculated for each combination of sex and age separately for cancer and cardiovascular disease, and these are used to simulate disease incidence. Before this can be done, a calibration of the combined attributable fraction is performed to ensure that the model reproduces the historically observed incidence. Calibration is done by adjusting the size of the attributable fraction corresponding to risk factors representing chance, genetic risk factors, and risk factors that are not included in the model. Calibration is performed by sex and age separately for each disease, and the calibration constants are denoted by $k_{s,a}$ in the equation below, where a denotes age and *s* denotes sex.

Simultaneously, the combined attributable fractions are calibrated to match the corresponding estimates from Brådvik et al. (2021) and Fridhammar et al. (2020). These calibration constants, denoted $k_{s,a}$, ensure that the proportion of new cases for each disease is proportional to the attributable fraction for the relevant risk factor.

$$P_{s,a} = 1 - \left(1 - k_{s,a} * cPAF_{s,a}\right)\left(1 - PAF_{s,a}^{0}\right)$$

The calibration described above is performed by comparing the simulated and observed intensity rates for incidence. This involves converting the attributable fraction into a corresponding intensity rate, which is then used to simulate the number of incident cases for each disease. The calculated calibration coefficients $PAF_{s,a}^{0}$ and $k_{s,a}$ are assumed to be constant over time.

An important aspect of model development is validation. The calibration of the combined attributable fractions is complemented by a check that the model can also generate a disease prevalence that is consistent with historically observed prevalence.

The underlying mathematical model

The graphical description of the relationship between NCDSim's stocks and flows, presented in Figure 1, also has a mathematical counterpart that is used when the model is simulated. For each of the model's stocks $S_{stock}(t)$, a differential equation specifies how the various flow components $F_{stock}^{flow}(t)$ affect the stock at time *t*. See the equations below:

$$\frac{dS_{nncd}(t)}{dt} = F_{nncd}^{born}(t) - F_{nncd}^{dead}(t) + F_{nncd}^{immig}(t) - F_{nncd}^{emig}(t) + F_{cvd}^{nncd}(t) - F_{nncd}^{cvd}(t) + F_{ccr}^{nncd}(t) - F_{nncd}^{ccr}(t)$$

$$\frac{dS_{ccr}(t)}{dt} = -F_{ccr}^{dead}(t) + F_{ccr}^{immig}(t) - F_{ccr}^{emig}(t) + F_{nncd}^{ccr}(t) - F_{ccr}^{nncd}(t)$$

$$\frac{dS_{cvd}(t)}{dt} = -F_{cvd}^{dead}(t) + F_{cvd}^{immig}(t) - F_{cvd}^{emig}(t) + F_{nncd}^{cvd}(t) - F_{cvd}^{nncd}(t)$$

The system of equations is solved numerically using the R package deSolve.

It should be noted that the model consists of 202 such systems of equations, one for each combination of sex and age group. Within each such combination, solving the equations gives the size of the stocks at the end of the current year. The method also makes it possible to calculate the model's flows during the current year. The process is repeated for each year within the selected simulation horizon.

Future scenarios

NCDSim is designed to enable exploratory analyses where the effects of changed assumptions—such as those concerning the prevalence of risk factors in the population—can be easily highlighted. The analyses are based on a baseline

scenario that serves as the reference against which the effects of changes can be compared and evaluated. By creating alternative scenarios with partially different assumptions than the baseline scenario, the effect of the alternative assumptions can be quantified.

Assumptions in the Baseline Scenario

A fundamental assumption in NCDSim is that the demographic development in the baseline scenario follows the projections made by SCB. Because the model accounts for differences in death risks between stocks based on empirically estimated death risks, an annual calibration of mortality by sex and age is required. This calibration ensures that the average mortality in the population does not deviate in the long term from the assumed mortality in SCB's projection, which gradually decreases over time. The calibration maintains the relative differences in mortality between stocks.

Furthermore, it is assumed that the empirically observed prevalence of risk factors in the population remains at current levels in the future, by both sex and age. If, in a particular analysis, a trend projection for the prevalence of one or more risk factors is desired, this can be relatively easily implemented through the model's user interface.

The relative risks used to simulate each risk factor's contribution to the total disease incidence are assumed to remain unchanged in the future.

The simulation-based estimates of average disease duration that are made separately for cancer and cardiovascular disease are assumed to remain unchanged over time.

Design and Analysis of Alternative Scenarios

Alternative scenarios can be used to study and quantify the hypothetical effects of interventions. This is typically done by reducing the prevalence of one or more risk factors as a result of an assumed or estimated effect of a specific intervention. Another application might be to illustrate the negative effects of a continued increase in a risk factor that shows an increasing trend.

In an alternative scenario with a different development of disease burden compared to the baseline scenario, mortality will also develop differently due to mortality differences between the healthy and diseased populations. Some effects might also arise in other demographic flows because these are simulated using intensity rates that are applied to the population. These are normally second-order effects because differences in mortality mainly occur at older ages when the impact of migration and nativity is small.

In NCDSim, explicit assumptions about the potential time delay between the intervention and its effect on health outcomes can be made by implementing a (linear) phase-in of the effect on the prevalence of a risk factor over a predetermined number of years.

When analysing an alternative scenario, it is usually the differences compared to the corresponding baseline scenario that are of primary interest, regardless of the outcome being analysed, be it incidence, prevalence, or costs. Whether absolute or relative differences are analysed often depends on the context and the outcome variable.

Calculation of Direct and Indirect Societal Costs

Cost Assumptions

Cost estimates include both direct medical costs and indirect costs, which are estimated as production loss during sick leave. All data on resource use in healthcare and cost data are from 2023. Future projections in the modelling are presented based on the 2023 cost level and the cost per patient, and these can be seen as a budget impact analysis. This means that future costs are not discounted. Historically, price development in healthcare has been greater than the inflation rate in society as a whole. However, this has not been adjusted for in the model because it is difficult to predict future relative price developments and to ensure that the analyses clearly show cost changes that are directly linked to changes in incidence and to population development.

Direct Costs

Healthcare costs for each diagnostic group are based on data from the KPP (cost-per-patient database) at the Swedish Association of Local Authorities and Regions (see Swedish Association of Local Authorities and Regions (2024)), which compiles the number of healthcare visits for specialised somatic care (divided into inpatient care and specialised outpatient care), as well as primary care and the average cost per visit. Only costs where the diagnoses within each disease group are stated as the main diagnosis have been included. Thus, there is no overlap between total costs for each disease group in our analyses, even if there is comorbidity between these conditions.

The KPP database does not cover all regions in the country. We have assumed that the regions included are representative of the country as a whole, and we scaled the costs to an assumed national total cost based on the coverage of each database.

Drug costs for prescription drugs are based on the National Board of Health and Welfare's prognosis report for the ATC group cardiovascular drugs (C), see National Board of Health and Welfare (2024). The total cost for cancer drugs (L01) is based on the Dental and Pharmaceutical Benefits Agency's estimates of total cost after rebate (through agreements between pharmaceutical companies and individual regions), see Dental and Pharmaceutical Benefits Agency (2024). For other drug groups, the rebate is assumed to be negligible, except for PCSK9 inhibitors (within the cardiovascular disease group), whose cost has also been adjusted to account for rebates.

Indirect Costs

Production loss due to illness is based on the Swedish Social Insurance Agency's public database (Swedish Social Insurance Agency (2024)) on the number of net

days with paid sickness and rehabilitation benefits by diagnosis. The statistics only include illness cases longer than 14 days because shorter sick leave is covered by the employer. The age distribution within each diagnostic group is based on data on the number of disease cases per age group from the Swedish Social Insurance Agency. Production loss was estimated by multiplying the number of net days by the average daily wage plus employer contributions for 2023 for each age group (average for all age groups: SEK 2,497 per day), adjusted for employment rate. Data were obtained from SCB's public databases.

Graphical User Interface

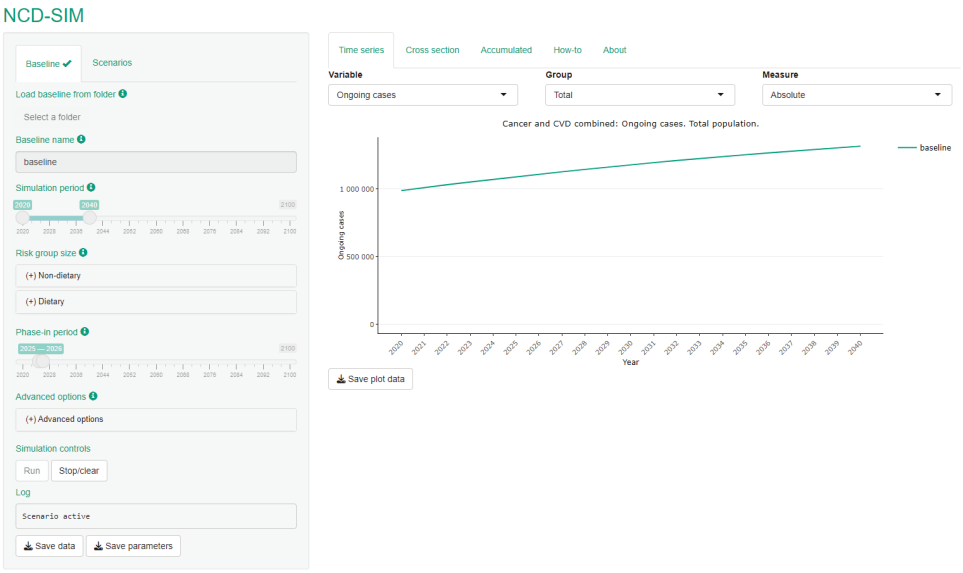
As mentioned, the model is written in the R programming language. During ongoing model development and for certain analyses, work typically involves writing and executing commands directly in the R development environment (usually RStudio). To make the model more practically useful, a graphical user interface with two main functions has been developed to:

- Perform new customised simulation runs
- Visualise results from the simulations

The interface is written in Shiny and functions as a web application with elements of R code. In the current version, the web app is designed to be used entirely on the local computer via RStudio. However, it is possible to construct a solution where the client computer, via the web app, can perform simulations on a server instead of on the local computer. The interface is available in Swedish and English versions.

The interface consists of a control panel (on the left) and a main panel for displaying the results in graphical form, see Figure 2. Through the control panel, various settings for the simulations can be made, such as the simulation period and the level of risk factor prevalence (the proportion at risk). One or more simulations can then be initiated by the interface by calling the simulation script in the background. Once a simulation is complete, the results can be saved to a file for later loading into the interface for further analysis.

Figure 2 – NCDSim's graphical user interface

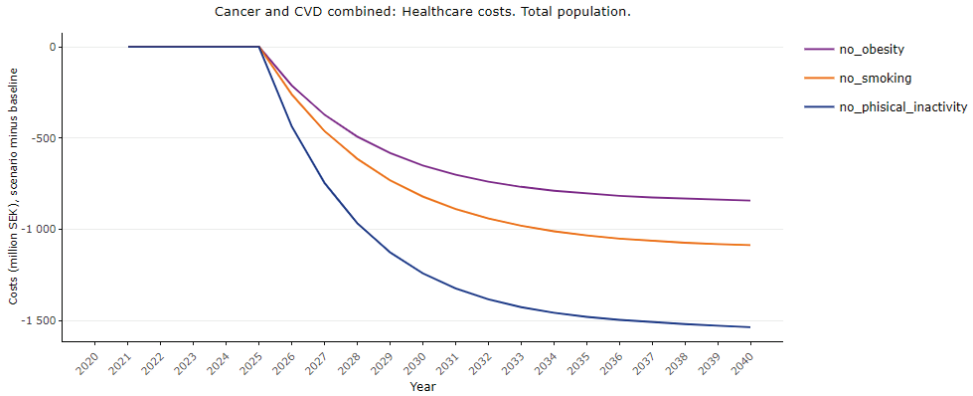


A baseline scenario must always be simulated first, or a pre-simulated baseline scenario must be loaded. All alternative scenarios generated during the same user session use the calibration constants from the loaded baseline scenario. These scenarios are generally not compatible with other baseline scenarios.

Alternative scenarios are generated or loaded from the Scenarios tab in the control panel. These scenarios share the same parameters as the baseline scenario, except for adjustment factors for the size of the risk groups, which can be changed to represent counterfactual developments (e.g., due to interventions). Multiple scenario simulations can be run in parallel, which is efficient for reducing waiting times.

The results are displayed in three separate tabs in the main panel, including time series, cross-sections (age distributions), and cumulative sums over several years for each scenario and group. For each type of graph, drop-down menus at the top of the screen can be used to select variables, groups, and measures. The results can be broken down by sex or age group, either in 10-year age groups or as above/below 70 years.

Figure 3 - Example of a Diagram in NCDSim's Graphical User Interface



The interface is useful for comparing different scenarios with each other. Figure 3 shows the development of healthcare costs in three different scenarios, presented as differences compared to the baseline scenario.

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