Estimating health-adjusted life expectancy conditional on risk factors: results for smoking and obesity

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Background

- Obesity and smoking are risk factors for chronic diseases that influence length of life:
  - Differences in life expectancy between smokers and never smokers have been found up to 10 years;
  - obesity leads to decreases of roughly 6 to 7 years in life expectancy.
- However, differences in LE alone are not sufficient to inform on the impact of unhealthy lifestyle:
  - they do not address the impact on quality of life through disabilities caused by chronic diseases
- Health-adjusted Life Expectancy (HALE):
  - the expectation of equivalent years lived in good health

Aims of this study

- Estimate HALE for different cohorts defined conditional on risk factors;
- Test whether obesity and/ or smoking prevention results in compression of morbidity

Methodology

- Estimated life expectancy (LE) and HALE for three different cohorts with the RIVM Chronic Disease Model (CDM):
  - a ‘healthy living’ cohort: a cohort of never smoking men and women aged 20 with a normal weight (BMI<25);
  - a ‘smoking’ cohort: a cohort of men and women aged 20 that smoke throughout their life with a normal weight;
  - an ‘obese’ cohort: a cohort of never smoking men and women aged 20 that with a BMI above 30.

Basic framework estimating HALE

$$HALE = \frac{\sum_{t} HSV(t) * N(t)}{N(0)}$$

HALE	*Health-Adjusted Life Expectancy*
HSV(t)	*Health State Valuation of the cohort at time t*
N(t)	*number of survivors of the cohort at time t*
N(0)	*initial size of the cohort at time 0*

Using the CDM we estimated the number of survivors and the health state valuations corresponding with the time dependent disease status of the different cohorts

Estimating Health State Valuations (HSV)

Independence between diseases and disability weights for comorbidity assuming a multiplicative model:

$$HSV(t) = \prod_{d} \left(1 - p_d(t) * w_d\right)$$

$p_d(t)$ *prevalence rate of disease d at time t*
w_d *disability weight for disease d*

For diseases causally related to obesity and smoking we used the CDM to estimate disease prevalence rates.

To capture the impact of diseases not causally related to BMI or smoking on disability we also used prevalence rates from the Dutch Burden of Disease Study for those diseases and assumed them constant over time.

The RIVM Chronic Disease Model (CDM)

Model of chronic diseases in the Dutch population

- Links risk factors to disease by relative risks
- Combines knowledge from different data sources
  - Disease incidence, prevalence and mortality (GP and national registrations)
  - Risk factor prevalence and transitions (cohort studies, cross sectional data)
  - Relative risks (international literature)
  - Demographic data (Statistics Netherlands)
  - Disability weights (Dutch Burden of Disease Study)

Risk factors

(e.g. smoking, BMI)

↓

Disease

(e.g. coronary heart disease, diabetes, several cancers)

↓

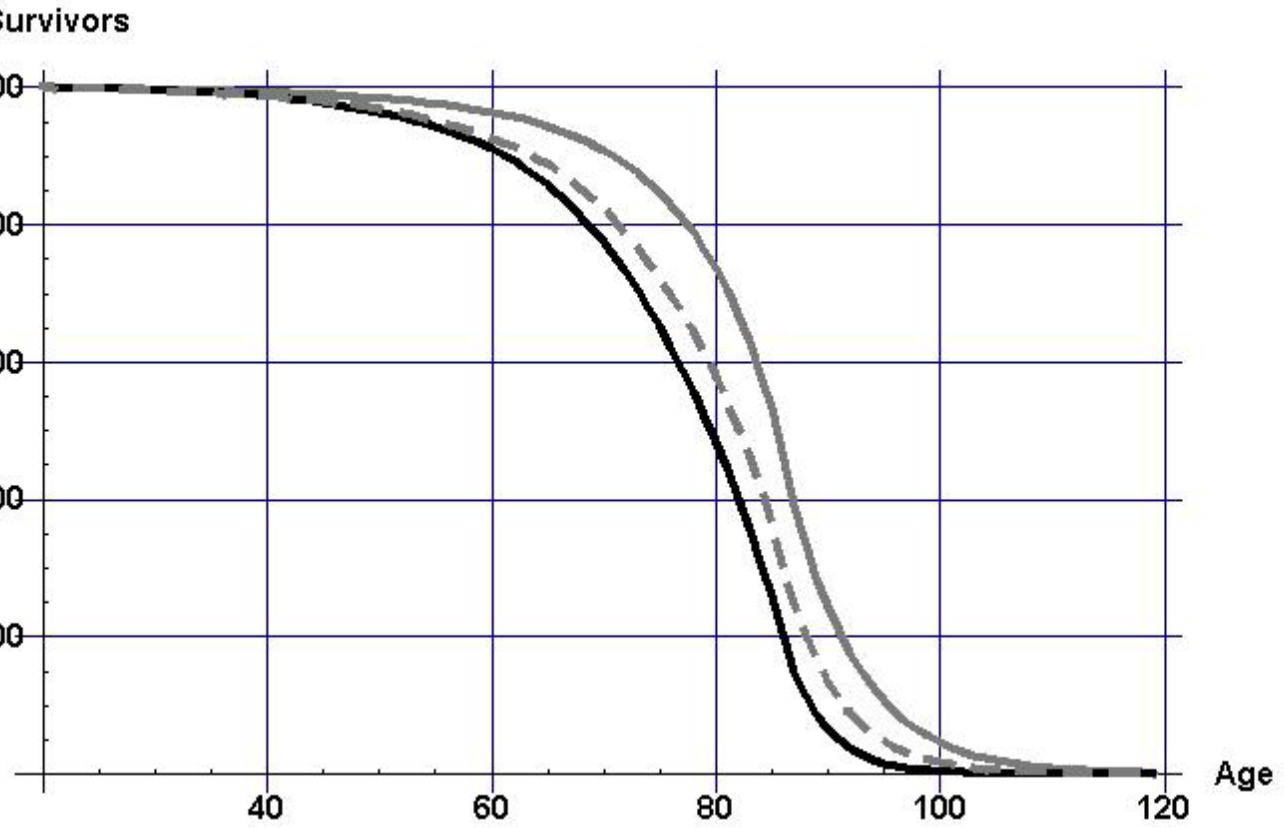
Mortality/Disability

Crucial assumptions in the CDM

- Independence between risk factors
- Multiplicative relative risks
- Additive disease specific attributable mortality rates
- Risk factor influences mortality through diseases and ‘other cause’ mortality
- Only current risk factor levels affect disease incidence (Markov)

Results

Survival curves for the different cohorts



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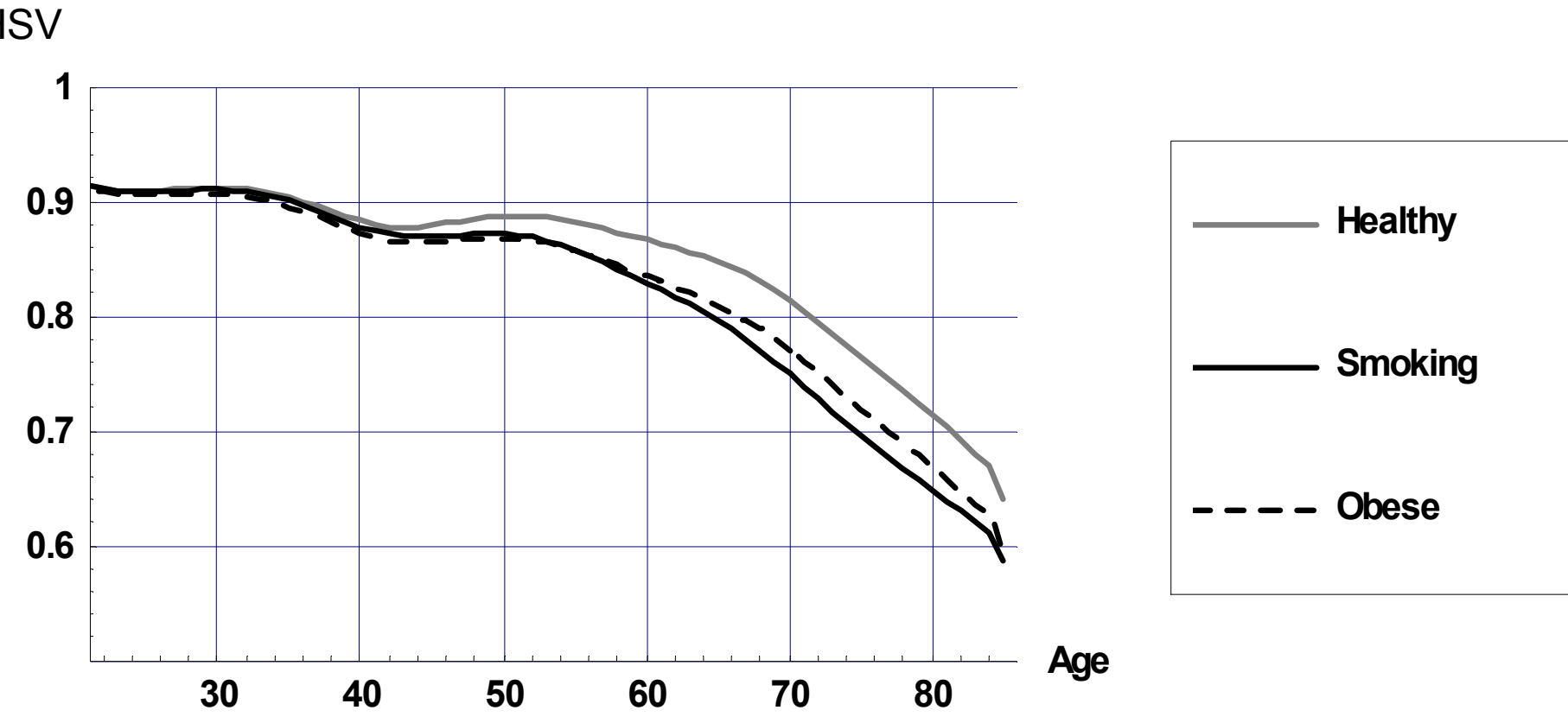
Average HSV of survivors



Cohort	LE	HALE	LE-HALE (LE-HALE)/L
Healthy living	64.4	55.1	9.3 0.14
Smoking	57.4	48.2	9.2 0.16
Obese	59.9	50.5	9.4 0.16

Conclusions

- ‘Healthy living’ cohort has highest LE and HALE
- Smokers (obese) have a 6.9 (4.6) years lower HALE compared to ‘healthy living’ people
- ‘Unhealthy years’ (LE-HALE) are approximately the same for all cohorts. Therefore, relative compression occurs if prevention is succesful

Discussion

- Data requirements:
  - we only modeled marginal disease prevalence rates, and did not model comorbidity (joint disease prevalence rates).
- To estimate baseline incidence and mortality rates for the 'healthy living' cohort:
  - independence between risk factor classes and multiplicative relative risks;
  - relative risks on disease incidence rates are used as an approximation for disease prevalence rates to estimate relative risk for the different cohorts on other causes of death.
- Excess vs attributed mortality rates:
  - The difference between the excess mortality and the part uniquely attributable to the disease can be interpreted as mortality due to co-morbid conditions……
- Disability weights for comorbidity:
  - Multiplicative….?
- Moreover…..


WAAROM BEN JE VAN DOOR GESTOPT MET ROKEN?!
SINDS DIE TIJD ZIJN ER KILO'S BIJ GEKOMEN EN NU HEB JE EEN GEVAARLIJK OVERGEWICHT...
SCHEELT ZES JAAR VAN JE LEVEN!
HUIS-ARTS

Estimating life years and disease prevalence rates with the CDM

$$\frac{dp(d \mid t)}{dt} = \left(i(d)_0 * RR(d \mid s_j) * RR(d \mid b_k) - em(d) * p(d \mid t)\right) * \left(1 - p(d \mid t)\right)$$

$p(d \mid t)$	*prevalence rate disease d at time t*
$i(d)_0$	*baseline incidence rate disease d for 'healthy living' cohort*
$RR(d \mid s_j)$	*relative risk for disease d for smoking class j*
$RR(d \mid b_k)$	*relative risk for disease d for BMI class k*
$em(d)$	*excess mortality rate disease d*

$$\frac{dN(t)}{dt} = RR(oc \mid s_j) * RR(oc \mid b_k) * m(oc)_0 * N(t) - \sum_d am(d) * p(d \mid t) * N(t)$$

$RR(oc \mid s_j)$	*relative risk for other causes mortality smoking class j*
$RR(oc \mid b_k)$	*relative risk for other causes mortality BMI class k*
$m(oc)_0$	*baseline other causes mortality rate for 'healthy living' cohort*
$am(d)$	*mortality rate attributed to disease d*

Calculating baseline mortality rates and risk factor class specific mortality rates

$$m(tot \mid s_j, b_k) = m(tot)_0 * RR(tot \mid s_j) * RR(tot \mid b_k) \qquad \text{(B1.1)}$$

$m(tot \mid s_i, b_j)$ *all cause mortality rate for cohort for smoking class j BMI class k*

$m(tot)_0$ *baseline all cause mortality rate for 'healthy living' cohort*

$RR(tot \mid s_j)$ *relative risk all cause mortality smoking class j*

$RR(tot \mid b_k)$ *relative risk all cause mortality BMI class k*

Using (B1.1) we can write the baseline mortality rate for the 'healthy living' cohort as:

$$m(tot)_0 = m_{tot} \Big/ \sum_{j,k} RR(tot \mid s_j) * RR(tot \mid b_k) * s_j * b_k \qquad \text{(B1.2)}$$

m_{tot} *population all cause mortality rate (Statistic Netherlands data)*

s_j *prevalence rate smoking class j (STIVORO data)*

b_j *prevalence rate BMI class k (POLS data)*

Calculating baseline disease incidence rates and risk factor class specific disease incidence rates

$$i(d \mid s_j, b_k) = i(d)_0 * RR(d \mid s_j) * RR(d \mid b_k) \qquad \text{(B2.1)}$$

$i(d \mid s_i, b_j)$ *incidence rate disease d for cohort smoking class j BMI class k*

$i(d)_0$ *baseline incidence rate for 'healthy' cohort*

$RR(d \mid s_j)$ *relative risk for disease d smoking class j*

$RR(d \mid b_k)$ *relative risk for disease d BMI class k*

$$i(d)_0 = i_d \Big/ \sum_{j,k} RR(d \mid s_j) * RR(d \mid b_k) * s_j * b_k \qquad \text{(B2.2)}$$

i_d *population incidence rate disease d (estimated using GP and national registrations)*