Healthcare Costs and Obesity Prevention
Drug Costs and Other Sector-Specific Consequences

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Abstract

Background: Obesity is a major contributor to the overall burden of disease (also reducing life expectancy) and associated with high medical costs due to obesity-related diseases. However, obesity prevention, while reducing obesity-related morbidity and mortality, may not result in overall healthcare cost savings because of additional costs in life-years gained. Sector-specific financial consequences of preventing obesity are less well documented, for pharmaceutical spending as well as for other healthcare segments.

Objective: To estimate the effect of obesity prevention on annual and lifetime drug spending as well as other sector-specific expenditures, i.e. the hospital segment, long-term care segment and primary healthcare.

Methods: The RIVM (Dutch National Institute for Public Health and the Environment) Chronic Disease Model and Dutch cost of illness data were used to simulate, using a Markov-type model approach, the lifetime expenditures in the pharmaceutical segment and three other healthcare segments for a hypothetical cohort of obese (body mass index [BMI] $\geq$30 kg/m$^2$), non-smoking people with a starting age of 20 years. In order to assess the sector-specific consequences of obesity prevention, these costs were compared with the costs of two other similar cohorts, i.e. a ‘healthy-living’ cohort (non-smoking and a BMI $\leq$18.5 and <25 kg/m$^2$) and a smoking cohort. To assert whether preventing obesity results in cost savings in any of the segments, net present values were estimated using different discount rates. Sensitivity analyses were conducted across key input values and using a broader definition of healthcare.

Results: Lifetime drug expenditures are higher for obese people than for ‘healthy-living’ people, despite shorter life expectancy for the obese. Obesity prevention results in savings on drugs for obesity-related diseases until the age of 74 years, which outweigh additional drug costs for diseases unrelated to obesity in life-years gained. Furthermore, obesity prevention will increase long-term care expenditures substantially, while savings in the other healthcare segments are small or non-existent. Discounting costs more heavily or using lower relative mortality risks for obesity would make obesity prevention a relatively more attractive option.
strategy in terms of healthcare costs, especially for the long-term care segment. Application of a broader definition of healthcare costs has the opposite effect. **Conclusions:** Obesity prevention will likely result in savings in the pharmaceutical segment, but substantial additional costs for long-term care. These are important considerations for policy makers concerned with the future sustainability of the healthcare system.

### Background

The increasing prevalence of obesity has become a public health issue in many countries. With around 1.5 billion adults worldwide being either overweight or obese and increasing prevalence rates among children, current and future attention to this problem is unsurprising. Especially since obesity has been found to cause coronary heart disease, hypertension, type 2 diabetes mellitus and certain types of cancer, therefore affecting the overall burden of disease and disability (and associated premature death). While the development and implementation of effective strategies to reduce the disease burden associated with obesity is clearly desirable from the perspective of public health, it has also repeatedly been suggested that this would also improve the financial sustainability of national healthcare systems.

Indeed, considerable economic costs are associated with obesity, and several studies have reported costs projections related to obesity concluding that obesity causes high medical expenditures. These findings suggest that preventing obesity, e.g. through lifestyle interventions, may not only lower the overall burden of disease, but at the same time decrease total healthcare expenditures. In an era where the ageing of populations and increasing longevity already pose additional challenges to the sustainability of healthcare systems, this may sound like good news indeed. Recently, however, van Baal et al. demonstrated that effective prevention of obesity may result in higher rather than lower lifetime medical costs. The savings due to preventing obesity-related diseases are offset in the long run by the additional costs of unrelated illness, especially in gained life-years. Many of the studies that report the opposite did not apply a lifetime perspective, excluding the unrelated medical costs in life-years gained from their cost projections. Therefore, as has previously been demonstrated for smoking, obesity prevention may eventually increase total healthcare expenditures (although this may clearly still be worthwhile given the health benefits).

As related and unrelated illnesses may be different in nature and in possible treatments, prevention strategies may not only affect the magnitude of future healthcare costs, but also the distribution of costs over different healthcare segments. Understanding this interaction is important, especially for the planning and financing of healthcare systems. Preventing obesity will most likely result in short-term savings in the curative sector due to a lower prevalence of obesity-related morbidity. Successful preventive strategies may reduce obesity-related morbidity but also increase longevity and the prevalence of unrelated diseases. This may influence the total amount of medical expenditures as well as the type of healthcare

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1. This implies that obesity affects both morbidity and mortality. While there is some debate about whether this is also true for the latter, much evidence suggests that obesity may indeed affect life expectancy negatively, especially among younger adults.
2. One study that does use a lifetime approach similar to the one followed by van Baal et al. is the previously mentioned study by Allison et al. These authors concluded that obesity prevention may lead to cost savings. Van Baal et al. offer several possible explanations for their different findings.
3. It is important to note that prevention may sometimes increase total healthcare expenditure due to an increase of related medical costs that are induced in life-years gained alone.
services needed. Indeed, “elderly persons use health care services at a greater rate than younger persons” and “the effects of longevity on expenditures for acute care differ from its effect on expenditures for long-term care”. Thus, changes in lifestyle may change future healthcare costs projections, not only at a total cost level, but also for the different segments of the healthcare sector.

As in other countries, obesity (prevention) may have important consequences for the Dutch healthcare financing system. The Dutch healthcare system consists of three compartments covering different types of healthcare services. The entitlements in the first two compartments, which together “offer all members of the public adequate cover against medical expenses,” are laid down in two mandatory insurance schemes, which are regulated differently. Long-term nursing care, home care and psychiatric care are covered in the first compartment, which is regulated by the government at a regional level under the Exceptional Medical Expenses Act (AWBZ) “under a regime of price and supply regulation.” GP care, pharmaceuticals and hospital care are all covered in the second compartment, which basically comprises all insurable, curative care regulated under the Health Insurance Act (ZVW). This latter scheme for curative care is based on regulated competition among private health insurers. Therefore, a substitution from one compartment to another compartment may have important distributional consequences among insurance schemes. Moreover, such a shift may prove to be even relatively more problematic if it is directed towards the first compartment (AWBZ), since possibilities of labour-saving technologies or increases in labour productivity are especially restricted in the area of long-term nursing and care, while a shortage of personnel is foreseen.

In this study, using a cohort approach based on Dutch empirical data, we use a similar but extended version of the model used by van Baal et al. to calculate annual and lifetime medical cost differences between obese and ‘healthy-living’ people (as well as smokers as an additional reference case). We focus on how prevention of obesity influences the breakdown of the medical costs into different segments and cost categories, especially highlighting the consequences of preventing obesity for lifetime spending on pharmaceuticals. Prior studies have mainly focused on the consequences of weight loss (interventions) on pharmaceutical expenses. However, less is known about the (lifetime) sector-specific cost consequences of obesity prevention. Since obese people use more obesity-related pharmaceuticals than people with normal weight, one may expect initial savings on drugs. In contrast, people with normal weight probably live longer and may therefore induce additional drug costs for diseases such as Alzheimer’s in additional life-years (with respect to obese people). Whether preventing obesity will result in cost savings in the drug segment may therefore importantly depend on how the savings on drugs for obesity-related diseases on the one hand relate to the additional drug costs in life-years gained on the other.

Methods

In order to estimate the effects of obesity prevention on the annual and lifetime healthcare costs in different segments, in particular the pharmaceutical sector, the Chronic Disease Model (CDM) developed by the Dutch National Institute for Public Health and the Environment (RIVM) was used in combination with Dutch empirical data from a cost of illness (COI) study from 2003. We briefly discuss the methods and input data used. For a more in-depth explanation of the RIVM CDM, we refer to Hoogenveen et al. and van Baal et al.

The National Institute for Public Health and the Environment Chronic Disease Model

The CDM is a Markov-type, multistate, transition model that describes the life course of different, hypothetical cohorts in terms of disease prevalence.

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4 Consumers may buy supplementary healthcare insurance from private health insurers for care that is not covered by either of the two Acts, i.e. care that is covered in the third compartment (e.g. cosmetic surgery and physiotherapy).
numbers, as well as mortality rates.\textsuperscript{5} In this study we used two risk factors, obesity and smoking, to simulate incidence and prevalence rates of 22 risk-factor-related chronic diseases, such as acute myocardial infarction, chronic heart failure, diabetes and different types of cancer. The risk factors and chronic diseases are linked by relative risks that are based on a wide range of international epidemiological studies. The prevalence of any chronic disease then determines the mortality risk (having a disease increases the risk of death) and thus the life expectancy.\textsuperscript{6} Moreover, mortality may also be a direct consequence of risk-factor-related diseases that are not explicitly included in the model.\textsuperscript{[13]}

We used a cohort analysis to estimate the disease prevalence and mortality rates of obese people and compare these numbers with healthy people and smokers. Three different cohorts are distinguished: an ‘obese’ cohort, a ‘smoking’ cohort and a ‘healthy-living’ cohort. All cohorts consist of 500 men and 500 women who initially are all aged 20 years. The obese cohort consists of men and women who have a body mass index (BMI) \(\geq 30\) kg/m\(^2\) and who have never smoked (and will never smoke).\textsuperscript{7} BMI is an internationally commonly used indicator of body weight (i.e. weight-for-height index expressed in kg/m\(^2\)). The WHO broadly recognizes four categories for adults according to predefined cut-off points: a BMI <18.5 kg/m\(^2\) is used to classify ‘underweight’; a person has ‘normal weight’ when his or her BMI ranges between 18.5 and 25 kg/m\(^2\); a BMI \(\geq 25\) kg/m\(^2\) indicates ‘overweight’; and a BMI \(\geq 30\) kg/m\(^2\) is used to categorize ‘obesity’\textsuperscript{[34]} The two reference cohorts that allow for disease prevalence and mortality rate comparisons are, first, a cohort consisting of people who are non-smokers and have a normal BMI (i.e. between 18.5 and 25 kg/m\(^2\)) [the ‘healthy-living’ cohort] and, second, a ‘smoking’ cohort of individuals with normal weight but who smoke throughout their entire lives. Furthermore, all cohorts are closed, meaning that there are no transitions among different cohorts (an obese person will never enter the ‘healthy-living’ cohort). Simulation of the cohorts proceeded for 100 simulations of 1 year until no survivors were left in any of the cohorts (i.e. nobody reached the age of 120 years). The CDM thus provides survival and prevalence numbers for diseases related to obesity and smoking. The prevalence of diseases unrelated to both risk factors (e.g. dementia) is considered equal for all cohorts. Therefore, prevalence numbers of such diseases will only depend on the number of survivors in each of the cohorts.

Cost of Illness Study

Linking the disease prevalence rates and cohort sizes to the healthcare costs per disease per patient divided per healthcare sector will result in estimations of annual and lifetime healthcare costs for different sectors of the three different cohorts. COI data from the Netherlands for 2003 were used to estimate these healthcare expenditures for the different cohorts.\textsuperscript{[21,35]} This COI study is a product of a collaboration of the center for Public Health Forecasting of the RIVM and the Erasmus University Medical Centre and Statistics Netherlands (CBS) and builds on previous editions of COI studies in the Netherlands. Specific methodologies for and previous results from these COI studies have been discussed elsewhere.\textsuperscript{[35,36]} These data can provide an overview of the total healthcare costs and related welfare expenditures in a specific year. Costs can be broken down according to disease, age and sex. Using such a top-down approach avoids any double counting and, therefore, cost estimates are both comprehensive and mutually exclusive. Furthermore, costs can be ordered according to the main

\textsuperscript{5} Among other things, the CDM has previously been used for projections of risk factors and disease prevalence rates, and cost-effectiveness analyses.\textsuperscript{[32,33]}

\textsuperscript{6} For example, smoking increases the chance of getting lung cancer, which subsequently increases the risk of dying. As a consequence, the life expectancy of smokers in the model is lower than the life expectancy of non-smokers.

\textsuperscript{7} The obese cohort is modelled as non-smokers to facilitate a clear interpretation of the substitution of diseases and its associated costs. Moreover, due to interactions between both risk factors with regard to mortality, it would pose additional data demands.
categories (i.e. diagnosis groups) of the ninth version of the WHO’s International Classification of Diseases, Injuries and Causes of Death (ICD) and further allocated to specific diseases. Beside this, costs can also be allocated to a wide range of more general categories, such as ‘sector’ (based on groups of healthcare providers), ‘all other infectious diseases’ and ‘not disease-related expenditure’.

Which costs are to be included in the cost estimations depends on the definition of care used. In this study, we used the Organization for Economic Cooperation and Development (OECD) System of Health Accounts (SHA), which focuses exclusively on healthcare costs as a consequence of direct medical care (diagnosis, treatment and nursing) and enables international comparisons. It is important to note that the SHA does not include some specific types of care allocated to the long-term care function, such as costs of home care. As such, the costs related to long-term care and, therefore, ageing, are underestimated. The segments used are those identifiable in the Dutch healthcare system. One feature especially relevant for the current study is that drugs used within the hospital are labeled as ‘hospital costs’, as they largely fall under the hospital budget in the Netherlands. We address this issue further in the discussion.

Analysis

In this study, we particularly focus on the costs of the four largest sectors: ‘medicines and medical appliances’, ‘hospitals’, ‘long-term care’ and ‘primary healthcare’. The CDM thus describes the prevalence numbers for 22 chronic diseases (specified by age and sex) related to obesity and/or smoking. Costs for the different cohorts are estimated by multiplying these prevalence numbers by the costs per patient per sector (also specified by age and sex). Diseases that are unrelated to obesity or smoking, such as dementia, are all included in a rest category. To calculate the costs of this rest category, the total costs per person per sector are deducted by the sum of the related costs of the 22 chronic related diseases per person per sector. This cost of the unrelated diseases is multiplied by the number of survivors for each cohort. The total costs per sector for the cohorts are calculated by adding the separate costs for all diseases (related) and the rest category (unrelated diseases). This allows comparisons of the annual and lifetime healthcare costs – the latter is obtained by summing the annual costs up over time – of the three different cohorts and estimating the consequences, in terms of costs for the different healthcare sectors, of eradicating obesity from the population.

Discounting

In order to assert whether preventing obesity results in cost savings in the pharmaceutical segment or any of the other major healthcare segments, we have to convert all the costs and benefits over time to the net present value. For this purpose, we discounted all costs and savings at a discount rate of 4%, which is in accordance with the Dutch national guidelines. To allow for international comparisons, we also calculated cumulative differences in healthcare costs between the obese cohort and ‘healthy-living’ individuals employing different discount rates, including discount rates of 0%, 3% and 5%.

8 Other definitions of healthcare costs available in the Netherlands are the Dutch Health and Social Care Accounts used by Statistic Netherlands (CBS) and the Budgetary Scheme of Care used by the Dutch Ministry of Health, Welfare and Sports. The first definition takes the broadest, societal perspective including some welfare costs and, for example, costs of housing and day nursery, while the latter includes costs that fall under the ministerial responsibility.

9 Note that we focus here on the consequences of prevention for healthcare costs, not on the costs of prevention itself. Therefore, we assume that the preventive intervention that would lead to this eradication (i.e. completely preventing obesity), is costless. Obviously, such interventions are hard to come by.

10 Discount rates for costs differ for different jurisdictions and national guidelines for pharmacoeconomic research. Discount rates usually range from 3% to 5%, although sensitivity analyses including discount rates from 0% to 6% are largely prescribed.
Sensitivity Analyses

As the application of the RIVM-CDM and the COI data require making various assumptions regarding key model input values and choosing between different definitions of healthcare costs (which may importantly influence the results), van Baal et al.\[13\] conducted several additional analyses. In this study, we also performed sensitivity analyses using similar starting points to van Baal et al.,\[13\] which we deemed especially relevant for our study.

First, we estimated the healthcare costs using the Dutch Health and Social Care Accounts healthcare costs definition (from Statistic Netherlands). This definition is broader than the SHA used in our base-case analyses and also comprises many types of social care, including care for the disabled, home care and day nursery. In the study by van Baal et al.,\[13\] the adoption of this broader definition had the biggest impact on their results—it increased the healthcare costs for all cohorts and also the relative differences between the three cohorts substantially. In our study, therefore, we expect this analysis to be especially relevant for the effects on the long-term care sector.

Second, no consensus has been reached regarding the exact association between BMI levels and risk of death. Variation in mortality risks for higher levels of obesity has been observed among several studies,\[43,44\] As we do not distinguish between levels of obesity (above a BMI of 30 kg/m\(^2\), relative mortality risks remain equal for all levels of obesity) and thus do not account for this variation in mortality rates, our lifetime medical costs estimates may be biased. Therefore, we examined the impact of varying the relative mortality risk associated to different levels of obesity. For this purpose and in line with van Baal et al.,\[13\] we used the relative mortality risks from Flegal et al.,\[44\] who used follow-up data from the series of National (US) Health and Nutrition Examination Surveys (NHANES). Flegal et al.\[44\] reported lower relative mortality risks for higher levels of BMI than cited in the international literature\[45-47\] (and used here). The input of these relative mortality risks into our model may influence the results for the obese cohort with regard to lifetime healthcare costs (as a consequence of lower mortality rates), which was also the case in van Baal et al.\[13\] In two separate scenarios, we applied the relative risk of mortality as reported in Flegal et al.,\[44\] first, the relative risk of mortality for BMI levels between 30 and 35 kg/m\(^2\) and second, for BMI levels ≥35 kg/m\(^2\).

Results

Life Expectancy

Life expectancies differ for the three different cohorts. Starting with 1000 people within each cohort, differences in mortality are negligible in the first 20 years. The main reason for this is that harmful effects of risk factors such as obesity and smoking predominantly effect mortality rates in the long run (in contrast to quality-of-life effects, which may also occur immediately). After 60 years (at the age of 80 years), 736 persons are still alive in the ‘healthy-living’ cohort as opposed to 483 people in the smoking cohort. The smoking cohort is the first cohort to become extinct, while the ‘healthy-living’ cohort is the last to lose all its members. Remaining life expectancies at the starting age of 20 years are thus longest for the healthy-living cohort (64.4 years), followed by the obese cohort (59.9 years) and the smoking cohort (57.4 years).

Annual Healthcare Costs

Figure 1 shows the average additional annual costs of an obese person compared with a ‘healthy-living’ person, conditionally upon survival. An obese person incurs higher medical costs for each of the healthcare segments than a person in the ‘healthy-living’ cohort, at all ages. However, the size of the differences in annual medical costs incurred by an obese and a ‘healthy-living’ individual differs significantly between healthcare sectors, the most notable difference being the annual hospital costs. To account for the differences in spending between healthcare sectors, figure 1b displays the annual cost ratio between the obese and ‘healthy-living’ cohorts. This lower panel shows that obesity has, relatively, the largest impact on medication spending. Between the ages of 30 and 40 years, an obese person spends, on
average, 25% more on drugs than a ‘healthy-living’ individual.

Expected Lifetime Medical Costs

Table I describes the results of the average expected lifetime costs, specified for each of the four healthcare sectors, per obese person, ‘healthy-living’ person and smoker. Furthermore, costs are divided into two parts: those costs attributable to obesity and smoking-related diseases, and costs attributable to other, unrelated diseases that occur in life-years gained. Summing up the costs for all risk-factor-related diseases suggests that obese individuals are most expensive and ‘healthy-living’ people most inexpensive. The obese cohort incurs the highest related healthcare costs within all sectors, except for long-term care. Drug spending for obesity-related diseases for an obese individual is on average €9200, compared with €7200 and €5200 for a smoker and a ‘healthy-living’ individual, respectively. For diseases other than those related to obesity and smoking, costs – which are much higher than costs attributable to obesity- and smoking-related diseases – are highest for the ‘healthy-living’ cohort, especially due to large differences in costs for long-term care. Average pharmaceutical expenditures per capita differ among cohorts: €26 300 for the obese cohort, compared with €24 300 and €29 800 for the smoking and ‘healthy-living’ cohorts, respectively. As shown in table I, total expenditure on medication and medical appliances are thus highest for the obese cohort. Total lifetime medical costs (summing all the segments up) are, on average, highest for a person in the ‘healthy-living’ cohort (€281 000) followed by a person in the obese cohort (€250 000) and smoking cohort (€220 000). The main reason for this is the difference in life expectancies among the different cohorts. The costs incurred in these additional life-years, in particular the costs for long-term care caused by diseases unrelated to obesity and smoking, are the foremost contributors to the cost differences between the three cohorts.

Obesity Prevention and Healthcare Costs

To analyse how prevention of obesity might influence the breakdown of the medical costs into different segments and cost categories, we used the differences in lifetime healthcare costs between the obese and ‘healthy-living’ cohorts. We assumed that the preventive strategy that would lead to this conversion (the obese cohort becomes the ‘healthy-living’ cohort) is costless. Figure 2 shows the cost differences for each of the four cost categories for the entire period (100 years) between the ‘healthy-living’ and obese cohorts. Future costs were discounted at 4%.

Figure 2 shows that during approximately the first 50 years, converting obese people into ‘healthy-living’ people will save costs in all segments (i.e. the four main segments) of the healthcare sector. The reason for this is that healthy people have lower disease incidence rates related to obesity and thus lower related medical costs. The largest savings occur in the pharmaceutical
and hospital segments. Savings in the medication segments are mainly a consequence of reduced medication and medication expenditures for diabetes, osteoarthritis and low-back pain. After this period, a different picture emerges. Preventing obesity results in the incurrence of additional costs in life-years gained in all healthcare segments, in particular in the long-term care sector. It also becomes immediately clear that the costs of long-term care explain that preventing obesity may increase rather than decrease healthcare costs.

From the age of 74 years, drug spending is higher for the ‘healthy-living’ than the obese cohort because of increased costs related to diseases such as Alzheimer’s and other diseases incurred in life-years gained. Despite this, lifetime expenditures on pharmaceuticals are lower when obesity is prevented – the cumulative difference in costs of pharmaceuticals between the obese cohort and the ‘healthy-living’ cohort is almost €1 million. Apparently, the savings on drugs for obesity-related diseases outweigh the additional costs for other diseases in life-years gained. Thus, successfully preventing obesity may result in cost savings in the short term, which would apply for all healthcare segments, but in additional expenditures in the long term, which sometimes outweigh the short-term savings. However, the medication segment (and the hospital segment, to a very small extent) will incur lower lifetime costs when obesity is successfully prevented, at the expense of higher costs elsewhere.

Discounting

The costs in figure 2 are discounted at a rate of 4%. The discount rate may importantly determine whether or not the short-term savings, which are the result of converting the obese cohort into the ‘healthy-living’ cohort, are outweighed by the additional costs incurred in the long run, i.e. whether or not preventing obesity will save costs in any of the healthcare segments. Table II presents the estimates for cumulative differences in healthcare costs if obesity is successfully prevented, using different discount rates. Not discounting will especially affect the cumulative long-term care expenditures, resulting in a €29 million difference in costs in that segment between the obese and ‘healthy-living’ cohorts. Applying a

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**Table I.** Expected lifetime medical costs per person (€ × 1000, year 2003 values) at 20 years of age for the three cohorts, categorized by sector

<table>
<thead>
<tr>
<th>Sector</th>
<th>‘Healthy-living’ cohort</th>
<th>Obese cohort</th>
<th>Smoking cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>related diseases</td>
<td>unrelated diseases</td>
<td>total</td>
</tr>
<tr>
<td>Long-term care</td>
<td>16</td>
<td>85</td>
<td>101</td>
</tr>
<tr>
<td>Hospital</td>
<td>19</td>
<td>49</td>
<td>68</td>
</tr>
<tr>
<td>GP</td>
<td>3</td>
<td>20</td>
<td>23</td>
</tr>
<tr>
<td>Medication</td>
<td>5</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>Other b</td>
<td>3</td>
<td>51</td>
<td>54</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>46</td>
<td>235</td>
<td>281</td>
</tr>
</tbody>
</table>

a Minor discrepancies with some of the totals may exist due to rounding of the cost estimates of the specific sectors.
b Includes the costs from all other sectors than the four explicitly listed in the table.
discount rate of 6% would reduce these additional expenditures to zero! The reason for this is that although preventing obesity will primarily increase the costs within the long-term care segment compared with the costs in the other segments, these costs are most likely to be incurred predominantly during the life-years gained, i.e. in the far future (after 50 years). Thus, if intervention costs are fixed, applying a higher discount rate for additional future costs due to obesity prevention will result in a reduction of total costs. This would make obesity prevention a more attractive strategy in terms of net present value (i.e. net present costs), even for the long-term care segment. For the medication and medical appliances segment and the two other healthcare segments, the choice of the discount rate seems to be of rather limited importance. In case of pharmaceuticals, obesity prevention will – regardless of the discount rate – always result in a reduction of lifetime costs.

Sensitivity Analyses

The results of the sensitivity analyses are shown in table III.

In scenario 1 (using the broader definition of healthcare costs from Statistic Netherlands: the Dutch Health and Social Care Accounts healthcare costs definition), absolute estimates of expected lifetime long-term care costs per person increase (almost by a factor of 2) for all cohorts, while costs in the other segments remain unaltered. Absolute cost differences for long-term care also increase between cohorts. Applying this broader definition of healthcare costs would make obesity prevention even less favourable (in terms of lifetime medical costs).

For the second additional analysis, we used the relative mortality risks for BMI levels between 30 and 35 kg/m² as reported by Flegal et al.,[44] who used data from NHANES – which are lower than used in our base-case scenario – as input values. Clearly, lower relative mortality rates for higher BMI levels will extend the life expectancy of the obese. This increases the difference regarding drug expenditures between obese and ‘healthy-living’ individuals. Moreover, it attenuates the differences in long-term care expenditures between the obese and ‘healthy-living’ cohorts (reducing the long-term care estimates for the latter, while increasing the long-term care costs for the former), but it slightly widens the gap for the hospital and GP segments (with higher expenditures for the obese cohort). In terms of total expenditures, applying lower relative mortality risks allows the obese people to incur more healthcare costs (as they live longer), which attenuates the differences in lifetime expenditures between the obese and ‘healthy-living’ cohorts. Preventing obesity will then be a relatively more attractive option – in terms of costs – with respect to the base-case scenario.

An almost similar pattern (but less pronounced) is shown in scenario 3 (relative mortality risks for the obese cohort based on NHANES BMI ≥35 kg/m²). However, in this case, pharmaceutical expenditures are similar to our base-case analyses.

Discussion

In this study, we used a Markov-type modelling approach to examine the consequences of obesity prevention for spending on pharmaceuticals and three other main Dutch healthcare segments, i.e. hospitals, long-term care and primary healthcare. We linked the RIVM CDM

<table>
<thead>
<tr>
<th>Sector</th>
<th>0%</th>
<th>1%</th>
<th>2%</th>
<th>3%</th>
<th>4%</th>
<th>5%</th>
<th>6%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long-term care</td>
<td>14</td>
<td>29</td>
<td>7</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Hospital</td>
<td>-1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>GP</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Medication</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
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<tr>
<td>Other</td>
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<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
We have shown that average annual drug expenditures – conditionally on survival – are higher for an obese individual than for a ‘healthy-living’ individual. More importantly, although obese people have a lower life expectancy than ‘healthy-living’ people (and thus have fewer years to induce drug costs), lifetime spending on drugs is higher for the obese. This can be explained by the fact that obesity increases the occurrence of diseases such as coronary heart disease, hypertension and type 2 diabetes, which require (extensive) drug treatment. Preventing obesity may first induce savings (i.e. savings in the first 50 years from the starting age of 20 years) on drugs for such obesity-related diseases. However, prevention also increases life expectancy. Still, the additional drug costs for diseases unrelated to obesity in the life-years gained through preventing obesity are outweighed by these early savings. In the end, therefore, obesity prevention (at zero costs) will result in cost savings for the medication segment. This holds in all sensitivity analyses and regardless of the discount rate used in the analysis.

For the other healthcare segments, consequences are most pronounced (and different from those for the drug segment) for expenditures on

### Table III. Expected lifetime healthcare costs per person: results of sensitivity analyses (€ x 1000, year 2003 values)\(^a\)

<table>
<thead>
<tr>
<th>Sector</th>
<th>‘Healthy-living’ cohort</th>
<th>Obese cohort</th>
<th>Smoking cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base-case scenario</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-term care</td>
<td>101</td>
<td>72</td>
<td>54</td>
</tr>
<tr>
<td>Hospital</td>
<td>68</td>
<td>68</td>
<td>64</td>
</tr>
<tr>
<td>GP</td>
<td>23</td>
<td>23</td>
<td>21</td>
</tr>
<tr>
<td>Medication</td>
<td>35</td>
<td>36</td>
<td>32</td>
</tr>
<tr>
<td>Other</td>
<td>54</td>
<td>51</td>
<td>49</td>
</tr>
<tr>
<td>Total</td>
<td><strong>281</strong></td>
<td><strong>250</strong></td>
<td><strong>220</strong></td>
</tr>
<tr>
<td><strong>Scenario 1 (broader definition of healthcare costs)</strong></td>
<td></td>
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</tr>
<tr>
<td>Long-term care</td>
<td>198</td>
<td>141</td>
<td>105</td>
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<tr>
<td>Hospital</td>
<td>68</td>
<td>68</td>
<td>64</td>
</tr>
<tr>
<td>GP</td>
<td>23</td>
<td>23</td>
<td>21</td>
</tr>
<tr>
<td>Medication</td>
<td>35</td>
<td>36</td>
<td>32</td>
</tr>
<tr>
<td>Other</td>
<td>54</td>
<td>51</td>
<td>49</td>
</tr>
<tr>
<td>Total</td>
<td><strong>378</strong></td>
<td><strong>318</strong></td>
<td><strong>271</strong></td>
</tr>
<tr>
<td><strong>Scenario 2 (relative mortality risks for the obese cohort based on NHANES BMI &lt;35 kg/m(^2))</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Long-term care</td>
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<td>82</td>
<td>51</td>
</tr>
<tr>
<td>Hospital</td>
<td>67</td>
<td>72</td>
<td>62</td>
</tr>
<tr>
<td>GP</td>
<td>23</td>
<td>24</td>
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</tr>
<tr>
<td>Medication</td>
<td>34</td>
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</tr>
<tr>
<td>Other</td>
<td>53</td>
<td>53</td>
<td>48</td>
</tr>
<tr>
<td>Total</td>
<td><strong>275</strong></td>
<td><strong>267</strong></td>
<td><strong>212</strong></td>
</tr>
<tr>
<td><strong>Scenario 3 (relative mortality risks for the obese cohort based on NHANES BMI ≥35 kg/m(^2))</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-term care</td>
<td>99</td>
<td>78</td>
<td>52</td>
</tr>
<tr>
<td>Hospital</td>
<td>67</td>
<td>69</td>
<td>63</td>
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<tr>
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<td>Medication</td>
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<td>31</td>
</tr>
<tr>
<td>Other</td>
<td>53</td>
<td>52</td>
<td>49</td>
</tr>
<tr>
<td>Total</td>
<td><strong>277</strong></td>
<td><strong>258</strong></td>
<td><strong>216</strong></td>
</tr>
</tbody>
</table>

\(^a\) Minor discrepancies with some of the totals may exist due to rounding of the cost estimates of the specific sectors.

**BMI** = body mass index; **NHANES** = National Health and Nutrition Examination Survey.
long-term care. Obesity prevention will increase long-term care lifetime expenditures substantially in the long run. The magnitude of the cost increase depends to a large extent on the definition of healthcare costs used, the relative mortality risk associated with obesity and the discount rate. Nevertheless, the additional expenditures will easily offset short-term savings, which are negligible since treatment of obesity-related diseases in normal life-years usually does not involve long-term care. On the other hand, in life-years gained, many unrelated diseases may be incurred that do require long-term care (such as Alzheimer’s disease). Thus, for the AWBZ sector (which is the financing scheme that accounts for long-term care), obesity prevention will result in (much) higher costs. This implies that the future sustainability of the long-term care sector will increasingly be challenged if policy makers are able to prevent obesity. Moreover, several projection studies show that population ageing will further increase the demand for long-term care considerably, posing additional challenges regarding the financing as well as planning of (future) long-term care.[48,49]

For the two other healthcare segments, i.e. hospital care and primary healthcare, overall consequences of obesity prevention are almost negligible. Although short-term savings are achieved in the hospital segment, additional costs in the long term almost completely offset these savings. Expenditures on GP care are hardly influenced by obesity prevention. Thus, although obesity prevention seems to have similar cost consequences for all healthcare segments – i.e. (relatively) short-term savings and additional expenditures in the long run – lifetime healthcare costs are affected in different ways for the different segments.

Previous studies show that changing lifestyles (into healthier ones) may be an efficient way to improve public health, even when medical costs in life-years gained are accounted for.[17,50-53] Although prevention may not lead to cost savings in every healthcare segment (and in terms of total healthcare expenditures), it may still be a rational thing to do if we can achieve better public health in a cost-effective way.[54,55] Therefore, it is important to realize that the substantial cost increase in the long-term care sector (and therefore rising total healthcare costs) as a consequence of obesity prevention does not imply that prevention of obesity is undesirable, but instead that much (policy) attention should be devoted to the future financing and planning of long-term care.

An important point in this context is where to draw the line regarding which costs to include in economic analyses (which may influence whether we perceive prevention as an attractive investment, in terms of costs, that is). In this paper it is clear that applying a broader definition of healthcare costs increases the absolute difference of estimates for long-term care expenditures between cohorts substantially, making obesity prevention less attractive with respect to the base-case scenario in terms of costs. This can be explained by the fact that the additional costs that are incurred in the long-term care segment as a consequence of obesity prevention are not purely medical expenditures, but consist mainly of costs for more public welfare services. However, such costs may not be directly relevant from a healthcare perspective, but more so from a societal perspective. If we extend our perspective into a complete societal one, more societal costs and benefits need to be considered. Less obesity means less obesity-related morbidity and higher life expectancies. This may increase, for example, the productivity of the working population, since obesity has been found to induce productivity losses[56-59] as well as provide the possibility to delay pension age. Furthermore, as the proportion of elderly grows in developed countries, healthy ageing may lead to a reduced strain on informal care (both financially and emotionally) as well as a stronger network of childcare. On the other hand, more costs will also be incurred that deserve consideration. Such costs, often referred to as survivor consumption costs, may be related to housing, food and clothes.[60] It need not come as a surprise that such considerations may importantly affect the consequences of (preventive) interventions, in terms of costs and effects.

Limitations

There are several limitations to our study that deserve mention. Some of these were already
discussed by van Baal et al.\cite{13} and will therefore not be extensively repeated here. First, we used the standard classification used by the WHO for overweight and obesity, i.e. according to BMI. It has been argued that this measure may have its limitations and that a combination of BMI and an indicator of how fat is distributed over the body – usually this is the waist circumference or waist-to-hip ratio – or even the latter indicator alone, would be more appropriate to assess the real health risk attributable to obesity.\cite{8,61}

Second, in the simulation approach we used, we have not incorporated any subdivision in BMI levels for people who are obese. Previous research has shown that this may be important for the relative risks and mortality rates related to obesity. We therefore performed two additional analyses using lower mortality risks for the obese, which show that the negative cost effects of obesity prevention on long-term care expenditures are attenuated compared with our base-case scenario, but still large enough to offset (slightly increased) savings in the three other main healthcare segments.

Another possible limitation of our model is that it does not account for the influence of variation in obesity on the cost per patient for every disease related to obesity. This implies that the costs of, for instance, treating low-back pain are independent of BMI level, which may not always be realistic.

Furthermore, an important limitation is that expenditures that result from pharmaceutical utilization within hospitals or intramural long-term care services were not included in the medication and medical appliances segment but were an inseparable part of the hospital costs and long-term care segment. This has to do with the current financing system of hospitals applied in the Netherlands, which implies that costs of intramural care, including medication, are largely part of the relevant institution’s budget. This implies that our estimates of medication expenses will likely be an underestimation and may also affect estimates of costs and savings in the different segments. Future work could therefore be aimed at further disentangling these costs.

A final noteworthy limitation of using the Dutch COI study is that assigning healthcare costs to diagnosis groups, age and sex is sometimes difficult. Detailed information regarding how cases were dealt with in which specific diagnosis data were lacking, information on the age distribution was missing or data had been miscoded is provided elsewhere.\cite{62}

**Conclusions**

The aim of this study was to show the consequences of preventing obesity for drug costs and other large segments of the healthcare sector. Obesity prevention will likely increase long-term care expenditures but induce savings in the pharmaceutical sector. This latter result is expected to be even more prominent as more and more obese people are being subjected to drug treatment. Despite possible cost increases as a consequence of obesity prevention, it may still be a worthwhile investment. This will to a great extent depend on how much health will be gained.\cite{63} These are important considerations for healthcare policy makers who are concerned with the future financing and planning of the healthcare system.

**Acknowledgements**

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