Tax interventions to reduce the burden of disease of type 2 diabetes

Thesis Master Health Sciences; School of Management and Governance, University of Twente.
07-07-2014, author: J. van den Akker, s0073337.

ABSTRACT

There is a substantial increase of type 2 diabetes in The Netherlands. It is suggested to increase prices of energy dense foods, or to decreases prices of low energy foods, as an intervention to lower caloric intake across the population. In this research the possible effects on type 2 diabetes in The Netherlands of such taxation based interventions are explored. A link is made between the weight impact of tax or subsidy interventions and prevalence, incidence and excess mortality of type 2 diabetes.

Current tax policies to reduce obesity were identified from recent literature via Scopus using a content analysis. 21 articles were analyzed and suggested interventions are a fat tax on high calorie foods, a fat tax on sugar sweetened beverages, a thin subsidy on diet sodas, and a thin subsidy on fruit and vegetables.

For four specific implementations a health impact assessment (HIA) up to the year 2025 was made using dynamic modeling with the DYNAMO-HIA program. This model is used to quantify projected changes in population health using a Markov based partial micro simulation. Changes in BMI levels were taken from the literature and used as input for the DYNAMO-HIA program.

A 10% tax on caloric soft drinks and a 10% subsidy on diet sodas is expected to reduce BMI levels respectively with 0,099% for men and 0,122% for women, and 0,071% for both men and women. Unfortunately a tax on food away from home and a thin subsidy on fruit vegetables suggest an increase of BMI levels. When simulated in the DYNAMO-HIA program a 10% tax on caloric soft drinks is expected to reduce prevalence of type 2 diabetes in The Netherlands by the year 2025 with 1700, and a 10% subsidy on diet soft drinks could reduce prevalence with 1200 by the year 2025.

The modelled reduction in excess number of deaths by type 2 diabetes are 23 for the thin subsidy on diet soft drinks and 32 for the fat tax on caloric soft drinks. Changes in cohort life expectancy are marginal at the level of an individual, but might for example run up to 132000 life years gained without type 2 diabetes for the cohorts of women in The Netherlands.

INTRODUCTION

There is a substantial increase of diabetes in The Netherlands. Point prevalence of diabetes among males between 1991-2011 doubled, for females it increased by 50%. Also the incidence of diabetes increased with a vast amount between 1991 and 2011: numbers vary from 50 to 70%. The number of patients will continue to increase in the future, solely based on demographic developments prevalence of diabetes will rise with approximately 33% during 2011 through 2030. One of the explanations for type 2 diabetes of the current trend is the increasing number of obese people, possibly combined with less physical activity and changes in their dietary patterns. (Baan & Poos, 2013)

There are several risk factors which increase the probability of developing type 2 diabetes (subsequently called diabetes): genetics, obesity, abdominal distribution of fat, lack of physical activity, diet (high intake of saturated fat & lack of fibers), and smoking. Many people have a combination of these risk factors, especially the interaction of several factors are a part of the creation of glucose intolerance. The most important risk factor is obesity, but independent of someone's weight, the physical activity level and diet are factors where changes can be made (Baan, Spijkerman & Kranen, 2013). At this moment half of the Dutch population is overweight or obese (Brink & Blokstra, 2013).

Interventions

Voiced concerns about this public health trend offer a solution via taxation or subsidy based interventions to increase public health. It is suggested to increase prices of energy dense foods, or to decreases prices of low energy foods, as an intervention to lower caloric intake across the population. A *fat-tax* has been proposed by Laurence (2009), a soda tax by Edwards (2011) and thin subsidy by Lordan & Quiggin (n.d.). The rationale of such interventions is that the tax results in an increase of the retail price of the product, thus decreasing demand. When demand falls, consumption also falls and this leads to a reduced energy intake. In turn a reduced intake of energy is expected to achieve weight loss across consumers and could benefit the public health.

This taxation based interventions were serious options in Denmark (Stafford, 2012): a fat tax had been implemented, but already has been rescinded, and the planned sugar tax was cancelled.

In this research the possible effects on diabetes in The Netherlands of such taxation based interventions are explored. A link is made between the weight impact of tax or subsidy interventions and prevalence, incidence and excess mortality of diabetes. Possible interventions and their impact on body weight are gathered from the literature, then population health outcomes are projected using a simulation for a Health Impact Assessment called DYNAMO-HIA.

METHODOLOGY

Research questions

To what extent can tax interventions be expected to reduce the burden of disease of diabetes mellitus (type 2) and what is their estimated effect on the prevalence, incidence, excess mortality & life expectancy of DM2 among the population of The Netherlands up to the year 2025?

- Which taxation or subsidy policies, e.g. on (un)healthy food and drinks or specific nutrients are currently known to reduce BMI?
- How will four specific taxation based interventions, e.g., fat-tax, soda tax, diet soda subsidy and a thin (fruit and vegetables) subsidy, affect BMI levels across the population?
- What is the effect of the proposed interventions on prevalence, incidence, excess mortality and DALYs of DM2 among the population of the Netherlands per intervention up to the year 2025?

Literature search

First knowledge on the subjects of diabetes and possible policy interventions was gained with searches on PubMed and Google Scholar using the keywords *diabetes*, *fat tax, diabetes AND tax* and *thin subsidy*. RIVM literature and suggestions by experts were also taken into account. The next searches were performed at the Utrecht University Library, when a relevant full-text article can't be accessed via this institution the library of the Twente University was used.

Sub question one and two are answered via a literature search using Scopus. Since Scopus also indexes the Medline and EMBASE databases, it is chosen with practicality reasons in mind to suffice with only searches via Scopus for this research. Furthermore only full-text articles were used and filters were set to only include articles in the English language and from the year 2000 and onwards.

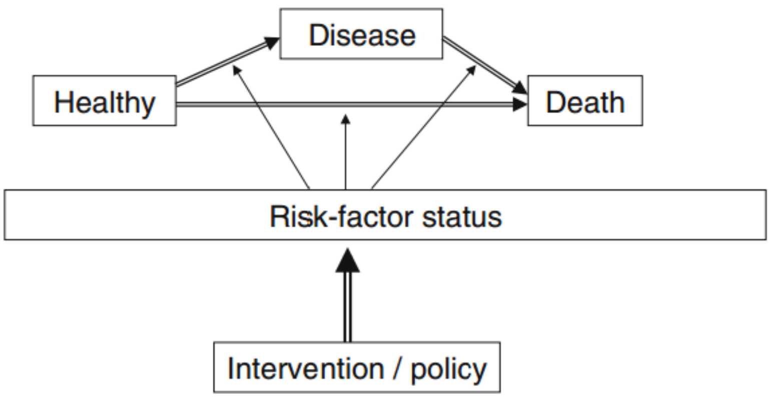
The exact query used on Scopus is: TITLE-ABS-KEY(tax AND policy AND obesity OR bmi) AND PUBYEAR > 1999 AND (LIMIT-TO(LANGUAGE,"English"))

Using a content analysis on the identified full-text articles, the current tax policies to reduce obesity were identified. A content analysis is a technique to analyze texts, according to Weber (1985) various methods are available: one can choose to code for each word, sentence, theme, paragraph or the whole text. Starting with the most cited article and noting the policy options provided by the author(s) we answer question 1. Also pros and cons of policy options were taken when stated by the author, when no new policies were found after 10 consecutive articles it was assumed to that all current policy options were retrieved. After reading the title or abstract an article could be excluded when it was believed to be irrelevant. For question two weight outcomes of the suggested interventions were noted when provided by the authors in terms of (expected) changes in BMI per intervention.

Dynamic modeling

Estimating the health effects of a specific policy or intervention on a population is called a Health Impact Assessment (HIA). HIA's are used to inform the decision making process. (Taylor & Quigley, 2002). DYNAMO-HIA (Dynamic Modeling for Health Impact Assessments) is a generic software tool to project the effects of specific interventions. DYNAMO-HIA specifically compares an intervention scenario with a baseline scenario. Furthermore the software program includes a comprehensive dataset of the population of European countries (including The Netherlands) This included dataset was composed by the DYNAMO-HIA project group and details are provided in several work package documents. For this research the data on overweight and obesity are relevant and can be found in 'Workpackage 7: Overweight and Obesity' by Lobstein & Leach (2010). Provided are age and gender specific data on mean BMI and the relative risk to diabetes.

This model is used to quantify projected changes in population health using a Markov based partial micro simulation as designed by the DYNAMO-HIA project and described by Lhachimi et al. (2012) & Boshuizen et al (2012). An initial population of individuals is modelled, based on the selected risk factor. The probability of a disease is also calculated for each simulated individual of the initial population, based on the selected prevalence rate. Then risk factor histories are simulated for each time step (1 year), both for the reference scenario and the intervention scenarios. From these risk factor histories, and the probability of a disease in the initial sate, the model calculates for the reference and intervention(s) scenarios the probability on disease and mortality for each simulated individual. (Boshuizen, 2010)



Concept of the HIA model - Source: Boshuizen et al. (2012)

For this research DYNAMO-HIA is used to project changes in prevalence, incidence, excess mortality of diabetes and cohort life expectancy for various scenarios. The answers to research questions 2 are used as input scenarios for the model. The interventions are modelled as changes in mean BMI of the included BMI prevalence file (Lobstein & Leich, 2010) and the model simulates the health impact and results are compared to the baseline reference scenario.

Using the DYNAMO-HIA model will probably underestimate the results because the proposed interventions influence diabetes incidence via the BMI risk factor. In the model the direct effects of a healthier diet on diabetes and it's disease management are not taken into account.

DYNAMO-HIA version 2.0-beta, with a release date of 13 October 2013, build 1228 is used for this research. This version was acquired from the developers at a master class by the Erasmus MC on February 7th 2014. DYNAMO-HIA is a free download provided by the DYNAMO-HIA project on www.dynamo-hia.eu, currently version 2.03 is available. Population and disease data is included in the model. See appendix 1 for the selected files and settings during the simulations.

Validity

During the content analysis the 11th article provided the fourth policy option. After coding for ten more articles no new interventions were found. It was assumed that after analyzing 10 consecutive articles no new options were found and all relevant options were identified. There is a possibility that more obscure or unpopular options were missed due to the selected number after to stop the analysis of new articles. Because it was anticipated to be difficult to find weight outcomes for the identified interventions it was chosen to start the analysis with the most cited article and continuing with to most cited article after that. Assuming there was more research on these most cited interventions, thus increasing the probability to find an answer to the second research question.

The DYNAMO-HIA program and it's calculations are described in detail on the project site, and the source code is available. The included dataset is visible in XML format and the source of this data is also provided on the website of the project. Thus the model itself and the underlying calculations are completely transparent. Every run of the model with the exact same input will produce the same results. The reported outcomes are only projections of quantified differences between the scenarios. The model can't predict future population health as such. (Lhachimi, 2012)

RESULTS

Suggested interventions in literature

The query '*tax AND policy AND obesity OR bmi'* yielded 207 results in February 2014. Using the content analysis the following policy options are found in the literature from 2000 until now. From the 21 analyzed articles, ranging from commentaries, to case studies, and interventions to reviews, 9 times some form of a taxation is suggested on high calorie of unhealthy foods; 14 times a tax on sugar sweetened beverages of sodas are mention. Only once a subsidy on a diet soda is mentioned and a subsidy on healthy foods (fruit/vegetables and/or low-calorie) is mentioned 5 times. 4 articles were excluded because they mentioned no tangible policy options, also some articles offer multiple options which is why the total number of policies exceeds the number of articles analyzed.

Found interventions	Number of mentions
Fat tax on high calorie foods	9
Fat tax on sugar sweetened beverages	14
Thin subsidy on diet sodas	1
Thin subsidy on fruit and vegetables	5

Nestle, M. & Jacobson, M.F. (2000) offer several suggestions: to levy a tax (city, state or federal) on soft drinks and other foods high in calories, fat or sugar, and use the revenues to fund campaigns to promote good nutrition and physical activity; and the subsidization of low-calorie nutritious foods, possibly by raising the costs of selected high-calorie, low-nutrients foods.

Brownell et al. (2009) goes into more detail and focusses on taxing sugar sweetened beverages (SSBs) via an excise tax in several forms. Options are to apply a tax of 1 cent per ounce for all beverages that have any added caloric sweetener, this may promote the consumption of no-calorie drinks. Or to tax beverages that exceed a threshold of 1 gram of sugar added per ounce/30ml, this would also promote calorie reduction and could be an incentive for manufacturers to use less sugar. Also a taxation assessed per gram of actual added sugar or the cancelation of sales tax exemptions are given, but this could be difficult to administer. Brownell & Frieden (2009) suggest a sales tax or an excise tax as fixed cost per ounce, the latter maybe providing an incentive to buy less. Again Brownell et al. (2010) suggests to tax SSBs with a penny per ounce and to earmark the revenue for obesity prevention programs or the subsidy of fruit and vegetables. Gostin (2007) proposes a fat tax in the form of a taxation of calorie-dense, nutrient-poor foods such as snacks, soft drinks, candy and chips.

Andreyeva, Chaloupka & Brownell (2011) suggest an excise tax of a penny per ounce on SSBs and estimate up to a 5lb per year loss of body weight when substitution effects are not taken into account. Powell & Chaloupka (2009) found some statistically significant association between food prices and weight outcomes and suggest a nutrient based food tax (fat tax) to tax specific categories of food with low nutritional levels such as soft drinks, candy, snack foods and fast foods. For low income household subsidies on healthy foods are preferred due to the regressive nature of a fat tax. Furthermore they state that small taxes are politically feasible and that revenues could be used for public health campaigns. Sturm, Powell, Chriqui & Chaloupka (2010) provide an tax on SSBs and estimate changes in children’s BMI and Powell, Chriqui & Chaloupka (2009) suggest a steep soda tax to reduce adolescent BMI.

Finkelstein, French, Variyam & Haines (2009) target fast food, carbonated beverages, and foods high in sugar and fat. Taxes are to reduce consumption and thus to reduce weight, the revenues can be used for the general budget or are earmarked for healthy weight campaigns. Kim & Kawachi (2006) come with a state-level taxation policy on soft drinks, snack foods and fast foods and Mytton, Clarke & Rayner (2012) offer to tax specific foods, tax specific nutrients, tax SSBs and a subsidy on healthy foods.

Lustig, Schmidt & Brindis (2012) compare sugar to alcohol an propose to add tax to any form of sweetened sodas, other SSBs such as juice, sport drinks and chocolate milk, and sugared cereal. E.g. a penny per ounce or 0,34 USD per liter. Sacks, Veerman, Moodie & Swinburn (2011) compare traffic-light nutrition labelling with a junk-food tax and suggest the latter, a tax on unhealthy foods is effective and cost-saving.

Two hypothetical interventions, a fat tax and a subsidization of fruit and vegetables are suggested by Faith, Fontaine, Baskin & Allison (2007). Options offered by Nnoaham, Sacks, Rayner, Mytton & Gray (2009) are taxing foods which are a major source of saturated fat, or taxing foods which are defined as less healthy on the WXYfm nutrient score, or the latter in combination with a low or a high subsidy on fruit and vegetables.

Schroeter, Lusk & Tyner (2008) researched 2 types of fat tax and 2 types of a thin subsidy: a food tax on food away from home and a food tax on soft drinks. And a food subsidy on fruit and vegetables and a food subsidy on diet soft drinks. Also they determined the weight impact of these interventions.

Interventions and their body weight impacts

While performing the literature search on Scopus only one research article was found which provided the answers to the second research question. Exact body weight impacts for various interventions are drawn from research by Schroeter, Lusk & Tyner (2008). Their study consists of an utility maximization framework, i.e. exercise and the quantity of consumed foods (high and low-calorie) are a function to body weight, in turn utility is specified as a function of body weight. Furthermore they use energy accounting and calculate weight elasticities for foods and exercise for the average US adult. Eventually they come to the price-weight elasticity per intervention which is needed for this research.

Schroeter, Lusk & Tyner (2008) operationalize fat tax as an tax on food away from home, under the premise that these foods are more calorie-dense then food at home. Soda tax is operationalized as an tax on sugar sweetened soft drinks. The thin subsidy is operationalized as a subsidy on fruit and vegetables, and as a subsidy on diet soft drinks.

Intervention			Weight impact (%)
10% Fat tax			
	Male		
		Food away from home	+0,196
		Caloric soft drinks	-0,099
	Female		
		Food away from home	+0,196
		Caloric soft drinks	-0,122
10% Thin subsidy			
	Male		
		Fruit & vegetables	+0,222
		Diet soft drinks	-0,071
	Female		
		Fruit & vegetables	+0,222
		Diet soft drinks	-0,071
***Source:* Schroeter, Lusk & Tyner (2008), p. 63**			

It is very interesting to note that two of the four intervention could have a positive weight impact. It is expected that a 10% tax on food away from home and a 10% subsidy on fruit and vegetable actually could lead to a weight increase of the population. In the case of food away from home fat tax according to this is explained by the fact that this intervention increase home food consumption because it’s a substitute for the food away from home category and “because many of the foods consumed at home are energy rich, total energy consumption actually increases.” according to Schroeter, Lusk & Tyner (2008, p.60). The authors mention this as a counter-intuitive result and suggest in their discussion section that these findings could be controversial and that more research on food choices and body weight is necessary.

The interventions which are expected to reduce body weight are the fat tax on caloric soft drinks and a thin subsidy on diet soft drinks. Although the effects are close the fat tax with a change in body weight of 0,099% for males and 0,122% for females is more effective than a thin subsidy on diet soft drinks with a change in body weight of 0,071% for both males and females.

Since the above mentioned are the only direct usable weight impacts for two fat tax intervention and two thin subsidy intervention found in the literature search the following intervention scenarios are modelled based on the numbers calculated by Schroeter, Lusk & Tyner (2008).

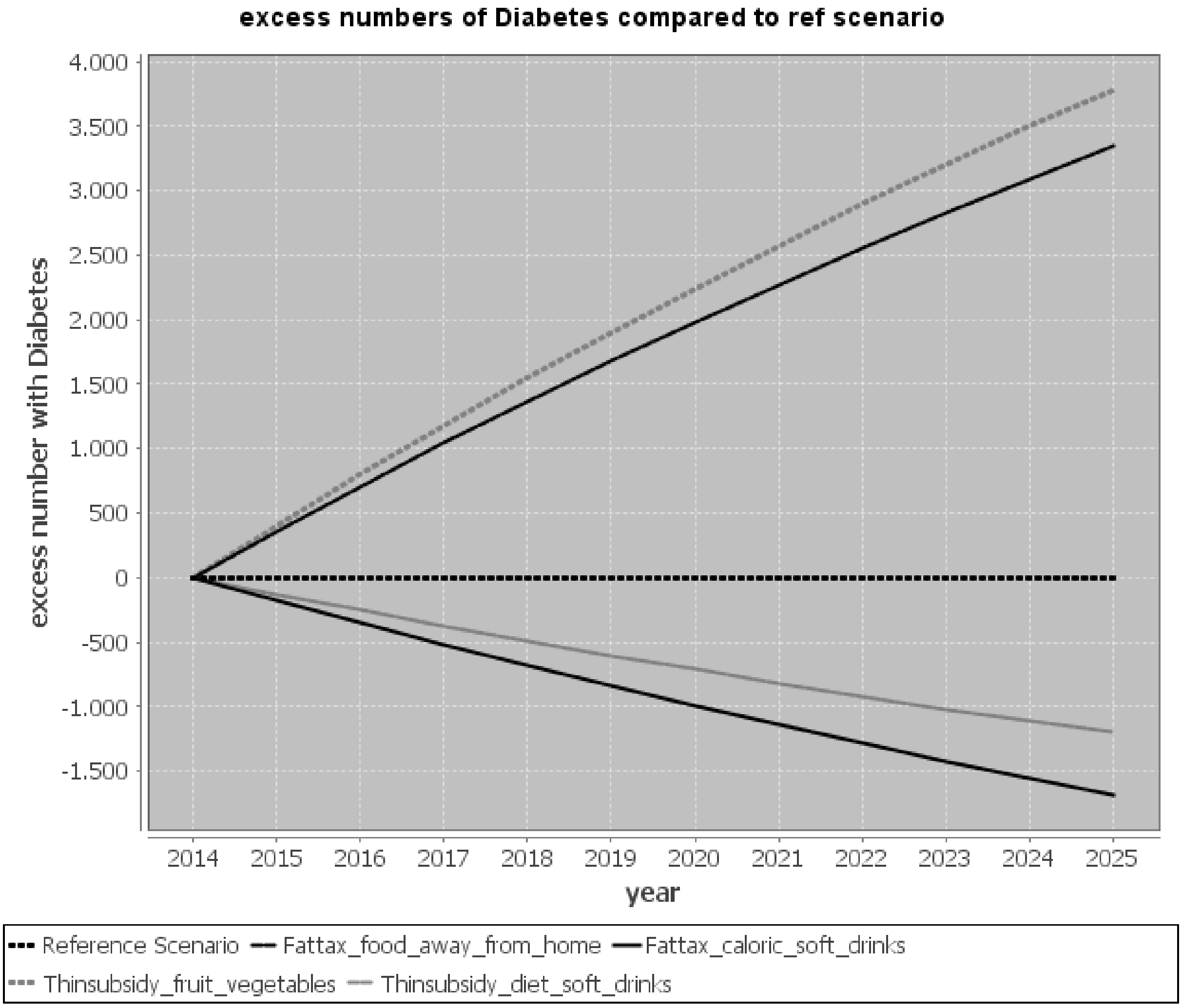
Dynamic modeling with DYNAMO-HIA

Although the by Schroeter, Lusk & Tyner (2008) calculated weight impacts are applicable for US adults it is assumed that they are similar for inhabitants of other western countries such as Dutch adults. This results in modeling the 10% fat tax interventions on food away from home and caloric soft drinks, and the 10% thin subsidy on fruit & vegetables, and diet soft drinks as changes in the mean BMI of the population of the Netherlands.

The baseline distribution of the BMI risk factor across the population of The Netherlands is included with the model (Lobstein & Leich, 2010). Per intervention the mean BMI for all Dutch adults is changed (males and females) with the impact provided by Schroeter, Lusk & Tyner (2008). E.g. the mean BMI of a 19 year old Dutch male is 21.3 for the baseline scenario, and 23.4 for a 24 year old Dutch Male. When an intervention with a 10% fat tax on caloric soft drinks is applied, the mean BMI of the 19 year old Dutch male changes to 21.278913 and to 23.376834 for the 24 year old Dutch male (both a reduction of 0,099%).

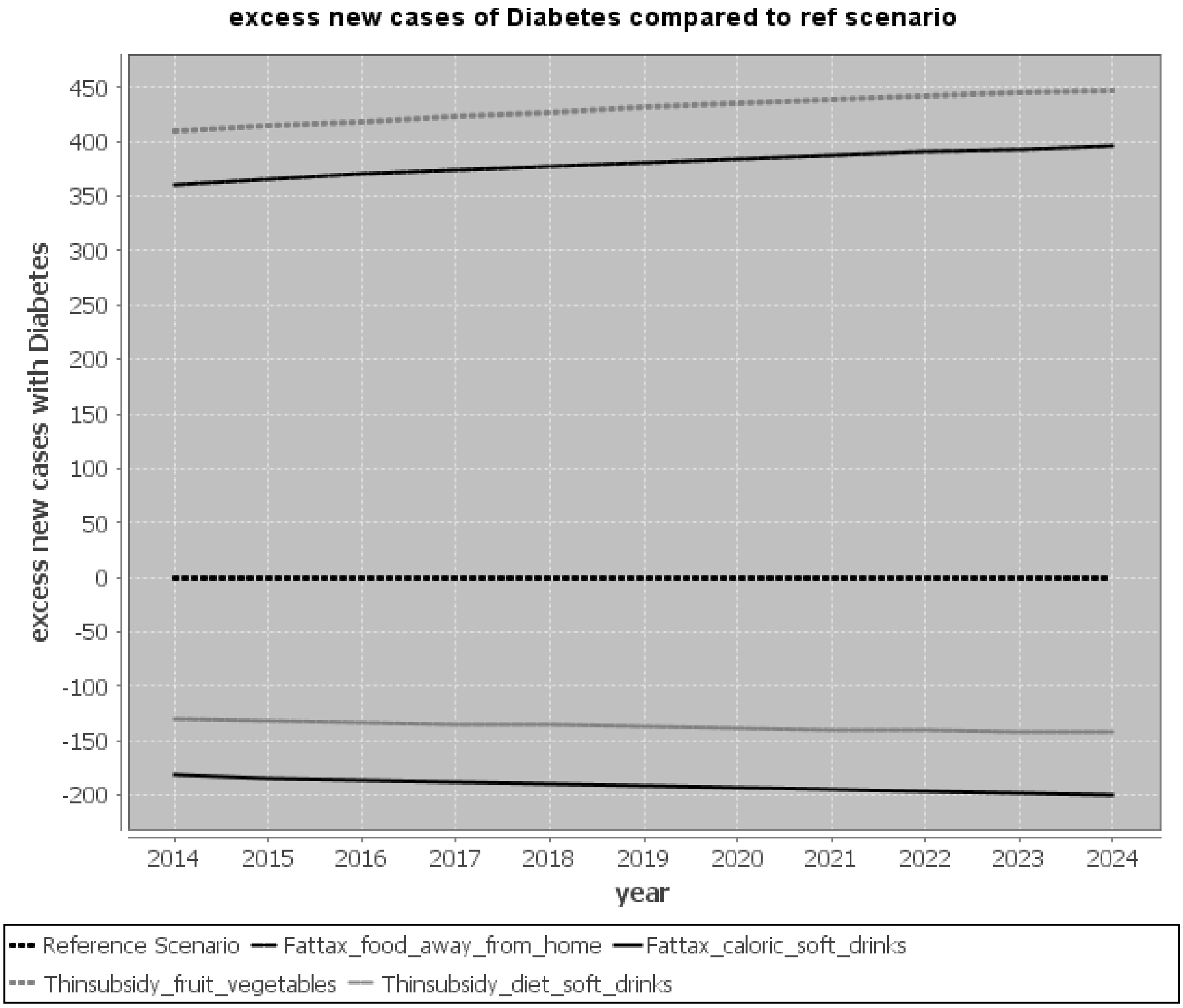
The interventions are applied on the adult population of the Netherlands via a new BMI risk factor prevalence file. 50 individuals of the Dutch population are modelled by DYNAMO-HIA from the year 2014 up to 2025. Newborns are included and the included ages are ranging from 0 to 95. For more details on the applied settings and the generation of the new BMI risk factor file in the DYNAMO-HIA software see appendix 1.

The following figures are the result of the dynamic modeling in the DYNAMO-HIA program. Respectively are shown the effects of the aforementioned interventions, in prevalence, incidence, and mortality of diabetes and life expectancy, compared to the reference scenario where no interventions are simulated. Effects for males and females are separately entered into the model, but combined to an average in the results.



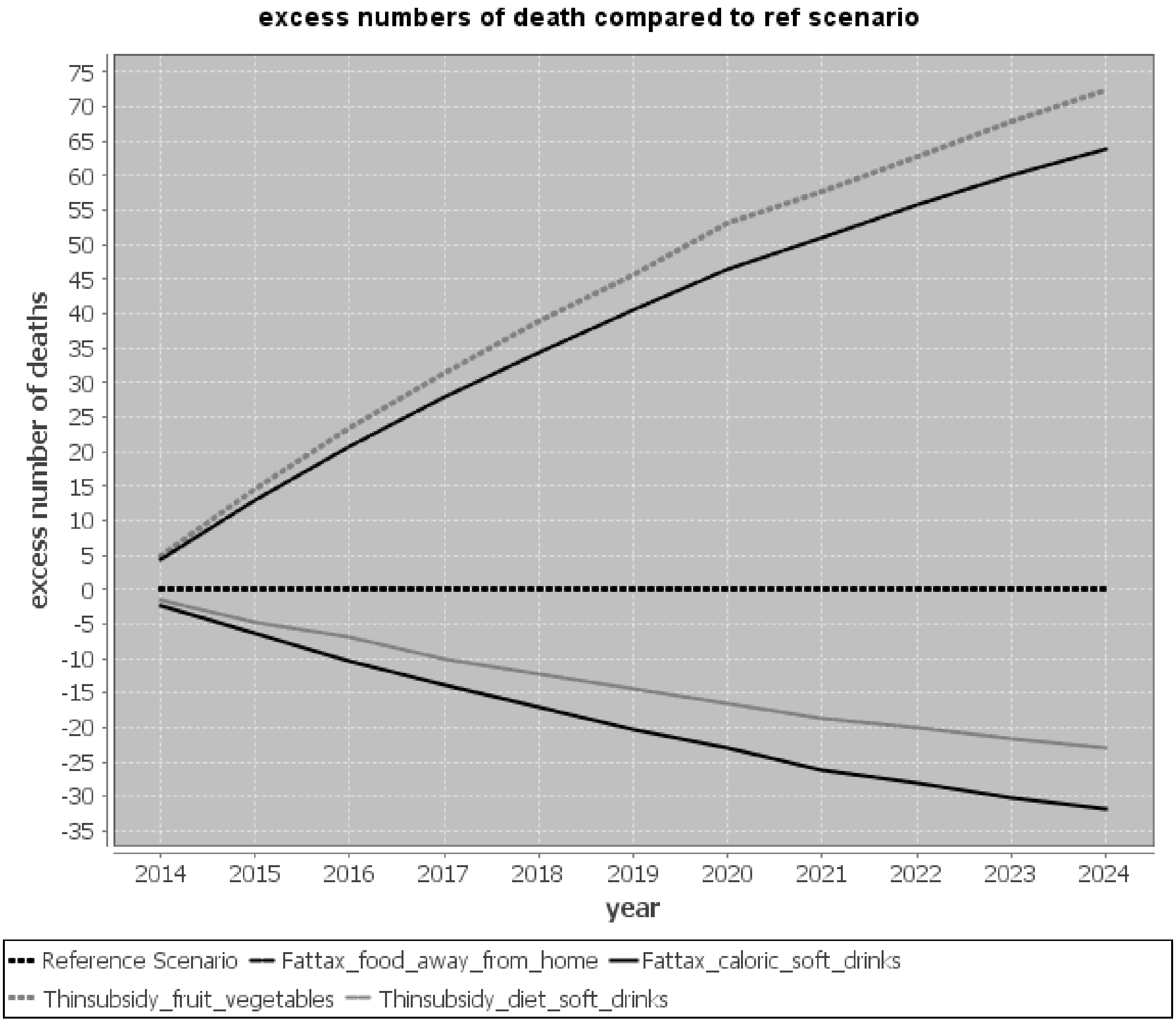
This graph shows the projected changes in prevalence of diabetes per intervention, compared to the reference scenario. The dotted grey line and dashed black line, corresponding respectively with a thin subsidy on fruit and vegetables and a fat tax on food away from home, show an increase of diabetes prevalence over the years. Compared to the reference scenario (dotted black line) where no intervention is applied, in the year 2025 there are approximately 3300 more people with diabetes when a 10% tax on food away from home is levied. And there approximately 3700 more people with diabetes when a subsidy on fruit and vegetables is applied.

A thin subsidy on diet soft drinks (continuous grey line) could reduce the prevalence of diabetes with approximately 1200 people. And with a fat tax on caloric soft drinks (continuous black line) this number would increase to approximately 1700 people.



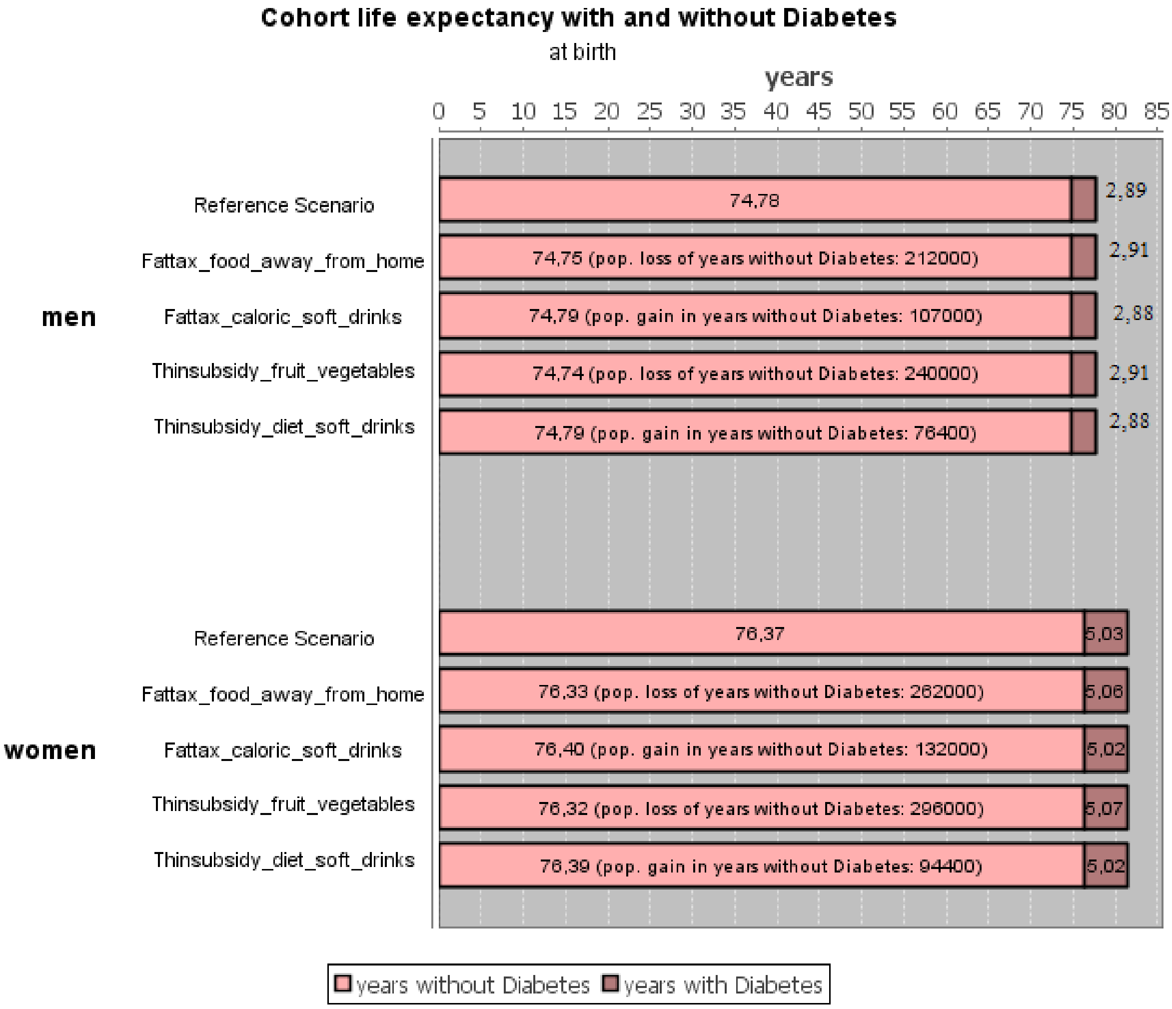
This graph shows the projected changes in diabetes incidence. The dotted grey line and dashed black line, corresponding respectively with a thin subsidy on fruit and vegetables and a fat tax on food away from home, show an increase of diabetes incidence over the years. Compared to the reference scenario (dotted black line) where no intervention is applied, in the year 2024 there are approximately 400 extra new cases of diabetes when a 10% tax on food away from home is levied. And there approximately 450 new cases of diabetes when a subsidy on fruit and vegetables is applied.

A thin subsidy on diet soft drinks (continuous grey line) could reduce the incidence of diabetes with approximately 140 people. And with a fat tax on caloric soft drinks (continuous black line) this reduction would increase up to approximately 200 people.



The projected excess mortality of the interventions is shown in this graph. For a food away from home tax 64 more people will die of diabetes in 2024 and for a thin subsidy this could run up to 72 excess deaths compared to the reference scenario.

A subsidy on diet soft drinks could prevent 23 deaths in the year 2024, and a tax on caloric soft drinks could prevent up to 32 deaths per year in 2024 compared to the reference scenario.



This chart shows the projected average life expectancy for men and woman in the reference scenario and for the four interventions. Population life years gained without or lost (without diabetes) are also included per intervention: e.g. when a fat tax on caloric soft drinks would be introduced it is projected that in total over all cohorts of Dutch women would gain 132000 life years without diabetes.

DISCUSSION

Conclusion

From 21 analyzed articles found on Scopus the fat tax, as an tax on unhealthy foods or a tax on caloric soft drinks, is very frequently mentioned. Sometimes the taxation of unhealthy food and drinks is combined with a subsidy for the healthier choice. It was difficult to find specified weight impacts for taxation based interventions. The research by Schroeter, Lusk & Tyner (2008) provides these impacts for four interventions and provides an essential connection in this paper from the literature search to the dynamic modeling.

Only two of the four by Schroeter, Lusk & Tyner (2008) proposed interventions are able to reduce BMI and thus prevalence of diabetes in The Netherlands. A 10% tax on food away from home and a 10% subsidy on fruit & vegetables could lead to an increase of BMI possibly due to substitution effects.

A 10% tax on caloric soft drinks and a 10% subsidy on diet sodas is expected to reduce BMI levels respectively with 0,099% for men and 0,122% for women, and 0,071% for both men and women. When simulated in the DYNAMO-HIA program a 10% tax on caloric soft drinks is expected to reduce prevalence of diabetes in The Netherlands by the year 2025 with 1700, and a 10% subsidy on diet soft drinks could reduce prevalence with 1200 by the year 2025.

The modelled reduction in excess number of deaths by diabetes are 23 for the thin subsidy on diet soft drinks and 32 for the fat tax on caloric soft drinks. Changes in cohort life expectancy are marginal at the level of an individual, but might for example run up to 132000 life years gained without diabetes for the cohorts of women in The Netherlands.

Unfortunately effects of other interventions could fully reduce these health gains and could ultimately have a negative health impact. A small decrease (of for example 0,1%) in mean BMI of the Dutch population is projected to result in a large number (about 100000) of life years gained without diabetes for men throughout the affected cohorts. And in terms of prevalence of diabetes a decrease of more than 1000 is projected by to the year 2025.

The answer to the main research question "To what extent can tax interventions be expected to reduce the burden of disease of diabetes mellitus (type 2) and what is their estimated effect on the prevalence, incidence, excess mortality & life expectancy of DM2 among the population of The Netherlands up to the year 2025?" is based on the modelled intervention very straightforward. Tax interventions can be expected to reduce the burden of disease of type 2 diabetes. There is great interest in the topic by the field in the form of fat taxes and thin subsidies. Although some interventions may actually increase BMI and thus produce an unwanted effect. More research is therefore necessary to identify which interventions actually have the highest potential to reduce mean BMI levels. What this research shows is that when effective interventions are implemented the health gains for the population in terms of prevalence of diabetes and population gain of years without diabetes are considerable.

Limitations

The literature search for research question one did not include a keyword for subsidy, this may be a possibility why most of the literature suggested repressive (taxation) interventions and less positive interventions to stimulate healthier dietary choices.

The Schroeter, Lusk & Tyner (2008) study focusses on US adults only, and finally provide only one single weight change result per sex and intervention. For practicality reasons it was assumed this effect is the same in a Dutch scenario. Furthermore the by Schroeter, Lusk & Tyner (2008) calculated results are not split per age or per age group. The effect has been applied to all simulated adults in the Netherlands. Also they do not provide confidence intervals on the calculated weight changes, for the subsidies the provided reason is "because standard errors exist neither for the price elasticities nor the food-weight elasticities." (Schroeter, Lusk & Tyner, 2008, p. 62). For the tax interventions no explicit reasons are given.

Then there is the feasibility of the analyzed tax and subsidy interventions. Most promising at this moment is the 10% fat tax on caloric soft drinks, according to Powel & Chaloupka (2009) such a small tax should be politically feasible to implement, especially when revues are earmarked for health campaigns. The income effects for lower income household could be greater due to the regressive nature of such tax interventions, thin subsidies are therefore preferred for this income group. Steeper tax intervention could have a greater effect on weight change, but the feasibility will probably be lower compared to the 10% fat tax.

Mattes & Popkin (2009) researched nonnutritive sweetener consumption in humans and kept discussion to tax non caloric sweetened beverages out of their research, but they point out it is argued that diet sodas could promote a preference for sweet tastes. Finally the effect of a tax on caloric soft drinks or sugar sweetened beverages is probably underestimated since the DYNAMO-HIA program only includes changes in BMI. This excludes the expected direct link between SSB intake and diabetes because of the high glycemic load and possible insulin resistance. (Malik et al. 2010)

Suggestions for further research

Since certain interventions could have a negative impact more research on real world effects is necessary before a subsidy on fruit & vegetables or a tax on food away from home is considered. The possibility that diet soft drinks could increase consumption of SSBs should also be researched before a thin subsidy of diet sodas is considered. The substitution effects could potentially transform a good idea into a policy option with negative effects, or the primary effect could only be small and unforeseen side effects may completely mitigate the projected results.

Further research is necessary to validate the weight impacts of US adults on the Dutch population. Will the proposed intervention have the same weight impact in other populations? Furthermore the outcomes of the DYNAMO-HIA modelling should be compared to other projection utilities. Finally it would be very interesting to explore higher taxes or subsidies, could they be more effective than smaller taxes?

Policy implications

The immediate implications for policymaking are currently small until further research has been conducted. At this moment every policy that has proven to reduce the BMI across the target demographic is worth attention. Possible health gains of weight reduction are widely known. This research has shown that for diabetes small weight changes show over time a remarkable reduction in disease prevalence. On the other hand research was found that shows that a specific intervention such as a tax on food away from home may actually increase BMI levels due to substitution effects, this demonstrates extra prudence when developing policy options. For instance real life or simulated tests should be used to verify these, currently only calculated, interactions between intervention and weight changes.

For the specific intervention of taxing SSBs it is unclear whether such an intervention could be implemented in a cost-effective way. Literature presented in the results section prefer sizable taxes which could increase effects, but prefer small taxes for political feasibility and revenues should be specifically earmarked for public health campaign. But Lusk (2014) argues that simply taxing SSBs to increase public health is not a guarantee for success: it is unclear of the effects of the earmarked revenues for public health campaigns actually add health benefits, and the problem of high consumption of SSBs and obesity remains complex on economic, political and societal levels.

REFERENCES

Andreyeva, T., Chaloupka, F.J. & Brownell, K.D. (2011) Estimating the potential of taxes on sugar-sweetened beverages to reduce consumption and generate revenue. *Preventive Medicine, 52* (6), pp. 413-416. doi: 10.1016/j.ypmed.2011.03.013

Baan C.A. & Poos M.J.J.C. (2013). Neemt het aantal mensen met diabetes mellitus toe of af? *Volksgezondheid Toekomst Verkenning, Nationaal Kompas Volksgezondheid.* Bilthoven: RIVM. Retrieved from http://www.nationaalkompas.nl/gezondheid-en-ziekte/ziekten-en-aandoeningen/endocriene-voedings-en-stofwisselingsziekten-en-immuniteitsstoornissen/diabetes-mellitus/trend/ on 26-09-2013.

Baan C.A., Spijkerman A.M.W. & Kranen H.J. van (2013). Welke factoren beïnvloeden de kans op diabetes mellitus? *Volksgezondheid Toekomst Verkenning, Nationaal Kompas Volksgezondheid.* Bilthoven: RIVM. Retrieved from http://www.nationaalkompas.nl/gezondheid-en-ziekte/ziekten-en-aandoeningen/endocriene-voedings-en-stofwisselingsziekten-en-immuniteitsstoornissen/diabetes-mellitus/welke-factoren-beinvloeden-de-kans-op-diabetes-mellitus/ on 17-04-2013.

Brownell, K.D., Farley, T., Willett, W.C., Popkin, B.M., Chaloupka, F.J., Thompson, J.W. & Ludwig, D.S. (2009) The public health and economic benefits of taxing sugar-sweetened beverages. *New England Journal of Medicine,* 361 (16), pp. 1599-1605. doi: 10.1056/NEJMhpr0905723

Brownell, K.D. & Frieden, T.R. (2009) Ounces of Prevention — The Public Policy Case for Taxes on Sugared Beverages. *New England Journal of Medicine*, 360 (18), pp. 1805-1808. doi: 10.1056/NEJMp0902392

Brownell, K.D., Kersh, R., Ludwig, D.S., Post, R.C., Puhl, R.M., Schwartz, M.B., Willett, W.C. (2010) Personal Responsibility And Obesity: A Constructive Approach To A Controversial Issue. *Health Affairs*, 29 (3), pp. 379-387. doi: 10.1377/hlthaff.2009.0739

Brink CL van den (RIVM), Blokstra A (RIVM). Hoeveel mensen hebben overgewicht? In: Volksgezondheid Toekomst Verkenning, Nationaal Kompas Volksgezondheid. Bilthoven: RIVM, <http://www.nationaalkompas.nl> Nationaal Kompas Volksgezondheid\Determinanten\Persoonsgebonden\Overgewicht, 25 september 2013.

Boshuizen, H.C. (2010). Detailed description of DYNAMO-HIA calculations. Oktober 2010. Retrieved from http://www.dynamo-hia.eu/Documents_and_Publications on 22-05-2014.

Boshuizen, H.C., Lhachimi, S.K., Van Baal, P.H.M., Hoogenveen, R.T., Smit, H.A., Mackenbach, J.P. & Nusselder, W.J. (2012). The DYNAMO-HIA Model: An Efficient Implementation of a Risk Factor/Chronic Disease Markov Model for Use in Health Impact Assessment (HIA). *Demography, 49*, pp. 1259 – 1283. doi: 10.1007/s13524-012-0122-z

Edwards, R.D. (2011). Soda taxes, obesity, and the shifty behavior of consumers. *Preventive Medicine,* 52(6), pp. 417–418. doi: 10.1016/j.ypmed.2011.04.011

Faith, M.S., Fontaine, K.R., Baskin, M.L. & Allison, D.B. (2007) Toward the reduction of population obesity: Macrolevel environmental approaches to the problems of food, eating, and obesity. *Psychological Bulletin, 133* (2), pp. 205-226. doi: 10.1037/0033-2909.133.2.205

Finkelstein, E., French, S., Variyam, J.N. & Haines, P.S. (2009) Pros and cons of proposed interventions to promote healthy eating. *American Journal of Preventive Medicine, 27* (3) SUPPL., pp. 163-171. doi: 10.1016/j.amepre.2004.06.017

Gostin, L.O. (2007) Law as a tool to facilitate healthier lifestyles and prevent obesity. *JAMA*, 297(1), pp. 87-90. doi: 10.1001/jama.297.1.87

Kim, D. & Kawachi, I. (2006) Food Taxation and Pricing Strategies to "Thin Out" the Obesity Epidemic. *American Journal of Preventive Medicine, 30* (5), pp. 430-437. doi: 10.1016/j.amepre.2005.12.007

Laurence, J. (2009). Time for a fat tax? *The Lancet, 373,* p.1597. doi: 10.1016/S0140-6736(09)60893-X

Lhachimi, S.K. et al. (2012). DYNAMO-HIA-A Dynamic Modeling Tool for Generic Health Impact Assessment. *PLoS ONE* 7(5): e33317. doi:10.1371/journal.pone.0033317

Lobstein, T. & Leach, J.R. (2010). Workpackage 7: Overweight and Obesity. Report on data collection for overweight and obesity prevalence and related relative risks. Retrieved from http://www.dynamo-hia.eu/Documents_and_Publications on 15-06-2014.

Lordan, G. & Quiggin J.,(n.d.) *Should we put a thin subsidy on the policy table in the fight against obesity-?* School of Economics, University of Queensland. Retrieved from http://www.uq.edu.au/economics/abstract/417.pdf on 20-8-2012.

Lusk, J.L. (2014) Are Sugar-Sweetened Beverage Taxes a Cost-Effective Means of Reducing Weight? *Canadian Journal of Diabetes, 38*, (1), pp. 9-10. doi: 10.1016/j.jcjd.2013.08.259

Lustig, R.H., Schmidt, L.A. & Brindis, C.D. (2012) The toxic truth about sugar. *Nature, 482*, pp. 27-29. doi: 10.1038/482027a

Malik, V.S., Popkin, B.M., Bray, G.M, Després, J.P., Willett, W.C. & Hu, F.B. (2010) Sugar-Sweetened Beverages and Risk of Metabolic Syndrome and Type 2 Diabetes. Diabetes Care November 2010; 33 (11), pp. 2477-2483. doi: 10.2337/dc10-1079

Mattes R.D. & Popkin B.M. (2009) Nonnutritive sweetener consumption in humans: effects on appetite and food intake and their putative mechanisms. *Am J Clin Nutr* 2009; 89 (1), pp. 1-14. doi: 10.3945/ajcn.2008.26792

Mytton, O.T., Clarke, D. & Rayner, M. (2012) Taxing unhealthy food and drinks to improve health. *BMJ (Online), 344* (7857), art. no. e2931. doi: 10.1136/bmj.e2931

Nestle, M. & Jacobson, M.F. (2000) Halting the obesity epidemic: A public policy approach. *Public Health Reports,* 115 (1), pp. 12-24. Retrieved from http://www.jstor.org/stable/4598478 on 20-1-2014.

Nnoaham, K.E., Sacks, G., Rayner, M., Mytton, O. & Gray, A. (2009) Modelling income group differences in the health and economic impacts of targeted food taxes and subsidies. *International Journal of Epidemiology, 38* (5), pp. 1324-1333. doi: 10.1093/ije/dyp214

Powell, L.M. & Chaloupka, F.J. (2009) Food Prices and Obesity: Evidence and Policy Implications for Taxes and Subsidies. *Milbank Quarterly, 87* (1), pp. 229-257. doi: 10.1111/j.1468-0009.2009.00554.x

Powell, L.M., Chriqui, J. & Chaloupka, F.J. (2009) Associations between State-level Soda Taxes and Adolescent Body Mass Index. *Journal of Adolescent Health, 45* (3 SUPPL.), pp. S57-S63. doi: 10.1016/j.jadohealth.2009.03.003

Rubin R.R., Peyrot M. (1999), Quality of life and diabetes, *Diabetes Metab Res Rev*, 1999; 15(3): 208-18.

Sacks, G., Veerman, J.L., Moodie, M. & Swinburn, B. (2011) Traffic-light nutrition labelling and junk-food tax: A modelled comparison of cost-effectiveness for obesity prevention. *International Journal of Obesity, 35* (7), pp. 1001-1009. doi: 10.1038/ijo.2010.228

Schroeter, C., Lusk, J. & Tyner, W. (2008) Determining the impact of food price and income changes on body weight. *Journal of Health Economics*, *27* (1), pp. 45-68. doi: 10.1016/j.jhealeco.2007.04.001

Spijkerman A.M.W., Baan C.A. & Eysink P.E.D. (2013) Wat is diabetes mellitus en wat is het beloop? *Volksgezondheid Toekomst Verkenning, Nationaal Kompas Volksgezondheid*. Bilthoven: RIVM. Retrieved from http://www.nationaalkompas.nl/gezondheid-en-ziekte/ziekten-en-aandoeningen/endocriene-voedings-en-stofwisselingsziekten-en-immuniteitsstoornissen/diabetes-mellitus/beschrijving/ on 17-04-2013.

Stafford, N. (2012). Denmark cancels “fat tax” and shelves “sugar tax” because of threat of job losses. BMJ 2012; 345:e7889. doi: 10.1136/bmj.e7889

Sturm, R., Powell, L.M., Chriqui, J.F. & Chaloupka, F.J. (2010) Soda taxes, soft drink consumption, and children's body mass index. *Health Affairs, 29* (5), pp. 1052-1058. doi: 10.1377/hlthaff.2009.0061

Taylor, L. & Quigley, R. (2002). Health Impact Assessment: A review of reviews, London: Health Development Agency. Retrieved from http://www.nice.org.uk/niceMedia/documents/hia_review.pdf on 09-04-2013.

Weber, R.P. (1985). Basic content analysis. Beverly Hills, CA: SAGE.

APPENDIX 1

DYNAMO-HIA settings

During all modeling runs with the DYNAMO-HIA software the following settings are applied and input files are chosen:

Include newborns, starting year 2014, minimum age 0, simulated population size 50, number of years 11, maximum age 95, random seed 1.

Risk Factor

Risk Factor: BMI_cont
Risk Factor Prevalence: NL_RF_BMI_cont_Prev_V1
Transition: NL_RF_BMI_cont_Transition_Netto.

Diseases

Disease: Diabetes
Disease Prevalence: NL_disease_Diabetes_Prev_V2
Incidence: NL_disease_Diabetes_Inc_V2
Excess Mortality: NL_disease_Diabetes_ExecMor_V
Disabling impact or DALYweight: DALY weights for disease

Relative Risk

From: BMI_cont
To: Diabetes
Relative Risk: RR_to_Diabetes-BMI_cont

As input for the scenarios the prevalence of BMI across the Dutch population is changed. The file selected under 'Risk Factor Prevalence' is modified. The results from research question 2 are per intervention/scenario applied to the current prevalence of the BMI risk factor (NL_RF_BMI_cont_Prev_V1), starting from the age of 18. This step is the modelled tax or subsidy intervention and effects in weight change are assumed to be immediate. The downloaded DYNAMO-HIA package provides an Excel macro to export the new file as an XML file which subsequently is imported in DYNAMO-HIA. Each new prevalence file is first run in a separate simulation as a reference scenario in order to automatically generate a corresponding transition file. This new transition file and the prevalence file with modelled intervention are selected in the scenario tab.