FOOD ACT!VE

North West of England

Sugar Sweetened Beverage Duty Model

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Summary

- This document describes a model of the impact of a duty on sugar sweetened beverages (SSBs) for Local Authorities in the North West of England.
- It follows on from an evidence review and insight work that has been carried out across the North West.
- The estimated volume of SSBs purchased per person per week in the UK has more than doubled between 1975 and 2007 from 512ml to 1142ml.
- This report uses best evidence to describe the impact a 20% duty would have on consumption of SSBs, and obesity rates and rates of obesity related diseases in the North West.
- We have also estimated the QALYs (Quality Adjusted Life Years) gained and the healthcare cost savings that could be generated by such a duty.
- We modelled a rational low and high scenario based on National Diet & Nutrition Survey (NDNS) data and the drinks manufacturers' data.
- We assumed a linear relationship between calories consumed, rates of obesity and obesity-related diseases.
- The overall impact is a reduction of between 3.3 and 10.2 kcals per person per day across the North West. The biggest change in calories is for Manchester (high scenario 12.8 kcals per person per day).
- We found that a 20% SSB Duty would reduce obesity rates, and obesity related diseases.
- A 20% SSB Duty should reduce adult obesity prevalence in the North West by 1.5%.
- Based on the high scenario (which is based on manufacturer sales data), a duty would result in approximately 600 fewer diabetes cases, 400 fewer stroke and coronary heart disease cases, 100 fewer cancer cases, and almost 10,000 Quality Adjusted Life Years (QALYs) gained per year across the North West.
- The duty should produce cost savings from a reduction in healthcare costs of treating obesity related diseases of around £3.9million p.a. for the North West. The value of the QALYs gained would be up to £200m per annum.
- A report by Briggs & colleagues (2013) predicted a 20% duty would generate £276m in revenue in the UK which would equate to roughly £30m a year in the North West. A report by Sustain estimated that a 20p per litre duty on SSBs would raise £1billion per annum in the UK, which would equate to around £109million for the North West.
- Any revenue could be spent on interventions to improve health such as subsidized healthy foods, walking and cycling, food growing co-ops.
- Recommendations for further research are discussed.

1. About this document

This document describes the methods and outputs from a Sugar Sweetened Beverage (SSB) Duty Model for the North West of England. There is also an Excel-based tool which compliments this report. This is to inform policy around potential lobbying for, or local implementation of an SSB duty. It is also to enable colleagues to understand the model and to critique any of the model inputs and outputs with a view to the model being based on the best logical structure, evidence and intelligence available. The aim of the model is to provide a view on the acceptability, mechanism of action and potential outcomes that would be associated with levying a duty on sugar sweetened beverages (SSBs), with the theory that a duty would reduce consumption, reduce average calorie intake, and therefore reduce rates of obesity and associated diseases. This model follows on from an evidence review and insight report which described the evidence for an SSB duty, and looked at people's attitudes and behaviour around SSB consumption. This work by Timpson and colleagues[1] included a question on acceptability of an SSB duty; 51.9% (84/162) of the survey participants felt that a 20% price increase for SSBs would be acceptable, with 48.1% (78/162) stating that it would not be. This model uses data and models that have already been produced and attempts to localise them based on available data. It should only be considered as a rough policy model and does not take into account all of the local variation that exists in income, consumption, calories, exercise, and other factors that will predict how successful an SSB duty would be in reducing consumption, and therefore reducing calories and sugar intake, and reducing obesity related diseases. This model should therefore be considered as a starting point that could be built on in future with a more nuanced model. This model does not take into account the additional effect an SSB duty should have on dental health, and on bone health. This could be also considered in a future iteration of the model.

2. Introduction

Directors of Public Health (DsPH) in the North West of England want to understand which interventions can be used to reverse the obesity epidemic. One policy intervention that has been recommended as having the highest potential impact[2] is a duty on sugar sweetened beverages (SSBs). These are beverages that contain added caloric sweeteners. These include sodas, fruit drinks, sport and energy drinks, sweetened ice tea drinks and other beverages that contain added caloric sweeteners. The UK Faculty of Public Health (UKFPH) have called for a 20p per litre excise duty on sugar sweetened beverages[3] based on the evidence from a paper by Briggs and colleagues and other evidence. [4] A report published by Sustain, the alliance for better food and farming, in 2013 called for a 20p per litre duty on sugary drinks which they said would raise around £1billion per year. Sustain suggested that "this money could be spent on a Children's Future Fund to improve children's health and protect their environment. This could include providing free and high quality school meals; improving food education and skills – such as cooking and growing – in schools; offering free and sustainably produced fruit and vegetable snacks in schools; and installing fresh drinking water fountains in schools.". [5] Hypothecated (ring-fenced) duties like this are rare in the UK; examples include the TV license, and congestion and motorway charges.

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[1] Timpson, H., Lavin, R. & Hughes, L. (2013). *Exploring the Acceptability of a Tax on Sugar-Sweetened Beverages: Insight Work.* Centre for Public Health, Liverpool John Moores University.)

[2] Frieden, T. R., Dietz, W., & Collins, J. (2010). Reducing Childhood Obesity through Policy Change: Acting Now to Prevent Obesity. Health Affairs, 357-363. doi:10.1377/hlthaff.2010.0039, p. 358.

[3] UK Faculty of Public Health (2013). A duty on sugar sweetened beverages: A position statement. http://www.fph.org.uk/uploads/Position%20statement%20-%20SSBs.pdf

[4] 7. Briggs ADM, Mytton OT, Kehlbacher A, Tiffin R et al. 2013. Overall and income specific effect on prevalence of overweight and obesity of 20% sugar sweetened drink tax in UK: econometric and comparative risk assessment modelling study. BMJ. 347, f6189

[5] Sustain (2013). A Children's Future Fund – How food duties could provide the money to protect children's health and the world they grow up in. sustainweb.org/publications/info/263

SSB duties have been implemented in 33 US states (on average at 5%), as well as a 5% tax in France and 10% tax Ireland.[6] Since 1981 Norway has a tax on sugar of 7.05 kroner per kg, while Denmark has recently abolished a soft drink tax that has been in existence since the 1930s, mainly as people were just buying their soft drinks over the border in Germany. Samoa has had an SSB tax since 1984, while Australia applied a 10% tax in 2000. Mexico has recently put a one peso per litre duty on SSBs.[7] The New York City Health Board has attempted to ban 'supersize' sugary drinks sales.

Sugar sweetened beverages are calorific drinks that have little nutritional value and are a source of empty calories as the human body does not register the calories that have been derived from them in the same way it detects calories from food. The human body has evolved to think that any liquid we consume is most likely to be water. People do not feel satiated after consuming liquid calories as they do from solid food calories. [8] When people reduce their SSB intake, they do not compensate by getting more calories from food. [9] In fact SSB consumption has been associated with greater consumption of salty foods.[10] Therefore reducing SSB intake should reduce the total calories consumed across the population and therefore reduce obesity rates over time.

In England, the most recent key policy document around obesity was '*Healthy Lives, Healthy People: a call to action on obesity in England* (2011)'[11]. This paper had a target of a reduction in obesity prevalence in both children and adults by 2020 and called for closer working with the food and drink industry (known as 'the responsibility deal') to reduce the nation's calorie uptake by 5 billion kcalories per day to promote a neutral energy balance. The document stressed that reducing calorie intake is much more important than increasing physical activity in reducing people's risk of diseases caused by obesity.

It is estimated that in the UK between the 1920s and the 1970s, people's average calorie intake reduced as their levels of activity reduced. However since then it is estimated that calorific intake has stabilised or increased slightly and levels of physical activity have continued to fall. Since the 1970s the UK has observed a continuous increase in the proportion of the population with a body mass index (BMI) in the overweight (BMI 25-29.9 kg/m^2) and obesity (BMI > 30 kg/m^2) ranges. BMI is not a totally accurate measure of health risk or body fat in individuals - so some people who are very muscular have high BMI, and people of Asian background experience diabetes risk at a lower BMI than people from white backgrounds- but BMI works as a measure for most people and most populations. Using past trend, forecasts predict a continued rise in obesity prevalence, from 26% to 41-48% in men and from 26% to 35-43% in women by 2030. Obesity levels in the UK are similar to those in the USA 15 years before. The main causes of obesity are as follows;

1. People not getting enough physical activity.
2. People doing less physical jobs and more office-based sedentary work (the "white collar revolution").
3. People being more sedentary at home - spending time on the internet, watching TV or playing computer games.
4. People having more labour saving devices so using less energy in doing housework.
5. People travelling more by car, and walking and cycling less.

[6] Bahl R. (2003) The uneasy case against discriminatory excise taxation: soft drink taxes in Ireland. Public Finance Review 31(510).
[7] Boseley, S. (2013) Mexico to tackle obesity with taxes on junk food and sugary drinks. *The Guardian*, 1 November 2013. http://www.theguardian.com/world/2013/nov/01/mexico-obesity-taxes-junk-food-sugary-drinks-exercise
[8] Pan A, Hu FB. (2011) Effects of carbohydrates on satiety: differences between liquid and solid food. Curr Opin Clin Nutr Metab Care. Jul 2011;14(4):385-390.
[9] Berkey CS, Rockett HR, Field AE, Gillman MW, Colditz GA. (2004) Sugar-added beverages and adolescent weight change. Obes Res 12: 778–88.
[10] He FJ, Marrero NM, MacGregor GA. Salt intake is related to soft drink consumption in children and adolescents: A link to obesity? Hypertension. 2008;51:629-634.
[11] Healthy Lives, Healthy People: a call to action on obesity in England (2011) Available at: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_130401

6. The relative decrease in food prices (which fell at 1% per year between 1987 and 2007, although have risen since).
7. People eating out more and not preparing food themselves; a high density of restaurants and fast food outlets.
8. People having less time to prepare food, with more families having both parents at work.
9. People eating more ready meals which are generally more calorific.
10. Intensive marketing of high calorie foods.
11. Children not being breastfed or only being breastfed for a very short time which increases their chance of being overweight or obese.
12. Smoking rates falling; when people quit smoking they often gain some weight, though not enough to make it preferable to smoke in health terms.
13. Psychosocial issues around food manifesting later in life; people who grew up in poverty but then have access to rich foodstuffs later in life.
14. People getting more calories from drinking alcohol; the average amount of alcohol per year drunk in England & Wales increased from 5 litres per year in the 1950s to over 11 litres per year in 2007.
15. People comfort eating - rates of social isolation and family breakup have increased.

Between 2010 and 2030, the obesity attributable disease risk in the UK is projected to add an excess 544,000 – 668,000 cases of diabetes, 331,000 – 461,000 of coronary heart disease and stroke and 87,000 – 130,000 cancers.[12] In addition, a continuing trend in obesity would present a loss of 2.2 – 6.3 million quality adjusted life years (QALYs) and higher annual health care costs of £648 million by 2020 and £2 billion by 2030. Prevalence of overweight and obesity increases with age and is generally higher in the older age groups from 45 years old onwards among both men and women.

A review of the economic impact of obesity across the world found that spend on obesity related diseases represented 0.7% - 2.8% of a country's healthcare costs and that obese people had healthcare costs that were typically 30% higher than people of healthy weight.[13] In the UK in 2006/07, obesity and overweight was estimated to cost the NHS £5.1billion, or around 5% of total NHS spending.[14] The Department for Health produced estimates of the cost of obesity for 2007, 2010 and 2015 which were available at old NHS Primary Care Trust (PCT) level, this included estimates for the North West. [15] The estimated total NHS cost of obesity and overweight for England in 2015 was £15.4 billion.

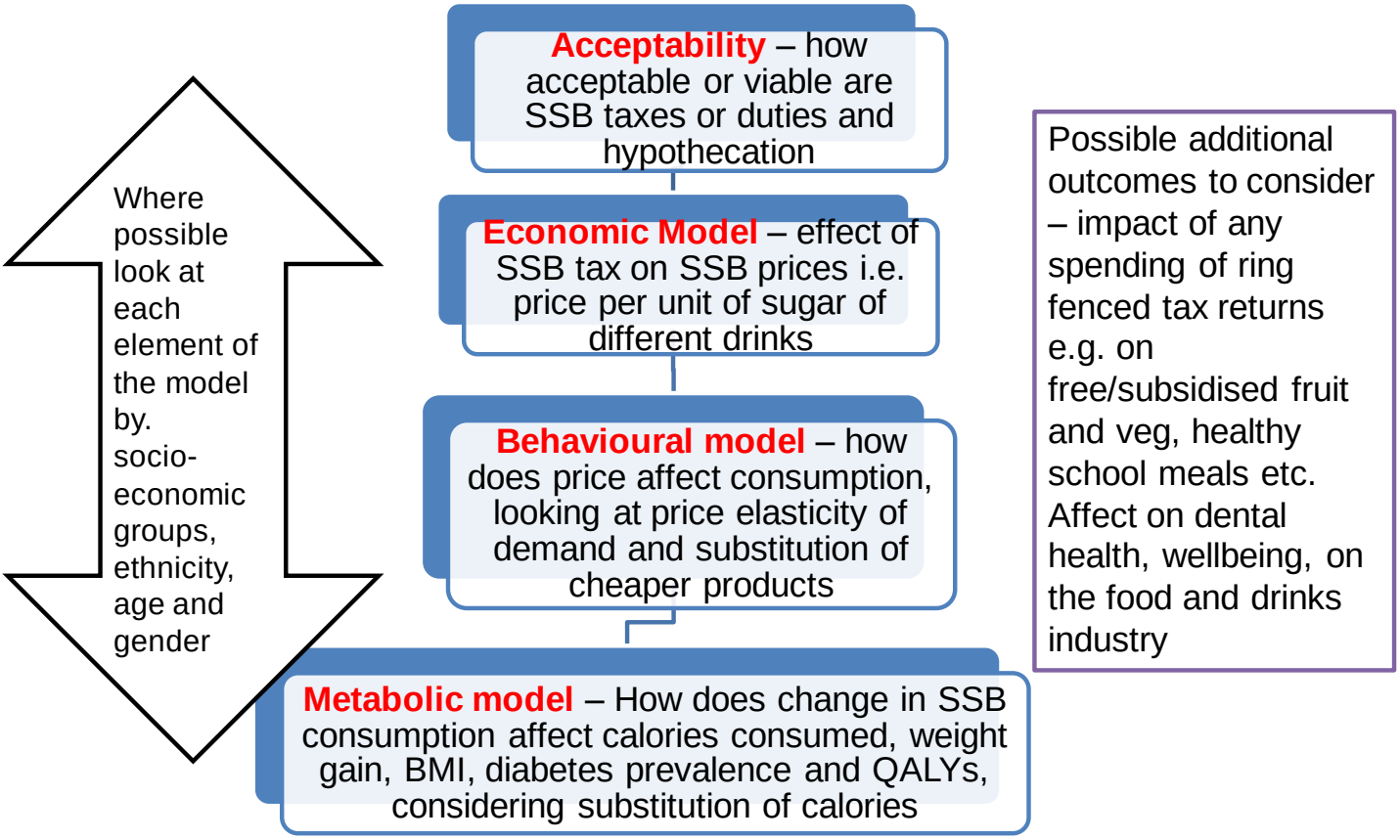
In recent years the focus in diabetes research has moved from fat and cholesterol being the predictors of diabetes, and towards sugar intake being a predictor of diabetes, independent of obesity rates. A review of the evidence around SSBs and diabetes found that individuals who had the highest consumption of SSBs had a 26% greater risk of developing type 2 diabetes than those with the lowest SSB consumption.[16]A recent study suggested that overexposure to sugar caused around a quarter of the increase in diabetes cases observed across 176 countries. [17] There has been debate over whether sugar is addictive; animal

[12] Wang YC, McPherson K, Marsh T, Gortmaker SL, Brown M (2011). Health and economic burden of the projected obesity trends in the USA and the UK. *Lancet*, vol 378: pp 815-25.
[13] Withrow D, Alter DA. The economic burden of obesity worldwide: a systematic review of the direct costs of obesity. Obes Rev 2011; 12: 131-141.
[14] Scarborough P, Bhatnagar P, Wickramasinghe KK, Allender S, Foster C, Rayner M. (2011) The economic burden of ill health due to diet, physical inactivity, smoking, alcohol and obesity in the UK: an update to 2006-07 NHS costs. J Public Health (Oxf). 2011 Dec;33(4):527-35. doi: 10.1093/pubmed/fdr033.
[15] Swanson, K. (2008) Healthy Weight, Healthy Lives: A toolkit for developing local strategies. National Heart Forum/Cross-Government Obesity Unit/Faculty of Public Health.
http://www.fph.org.uk/healthy_weight,_healthy_lives%3A_a_toolkit_for_developing_local_strategies
[16] Malik VS, Popkin BM, Bray GA, Despres J-P, Willett WC, Hu FB. Sugar-sweetened beverages and risk of metabolic syndrome and type 2 diabetes: a meta-analysis. Diabetes Care 2010;33:2477–83.
[17] Basu S, Yoffe P, Hills N, Lustig RH (2013) The Relationship of Sugar to Population-Level Diabetes Prevalence: An Econometric Analysis of Repeated Cross-Sectional Data. PLoS ONE 8(2): e57873. doi:10.1371/journal.pone.0057873

studies have found that sugar stimulates dopamine receptors in the nucleus accumbens similar to the action of cocaine.[18] Most sugar in Europe is from sugar beets, but the UK still import and refine a lot of sugar cane, mainly from commonwealth countries.

Figure I1 shows a schematic of how a sugar sweetened beverage duty model would work. This was the structure we followed to get data to inform the model. In reality we did not model acceptability in detail and used already published modelled estimates for the relationship between calorie intake and obesity.

Figure I1. Schematic of Sugar Sweetened Beverage Model.



[18] Rada P, Avena NM, Hoebel BG. (2005) Daily bingeing on sugar repeatedly releases dopamine in the accumbens shell. Neuroscience. 134:737–44.

3. Model Inputs

3.1. Daily calorie intake data

Based on survey estimates people in Britain consume an average of 137-156 ml each day of sugar sweetened drinks. Based on manufacturer data people consume an average of 478 ml each day, or around 3-4 times as much.[19] This equates to around 50 kcal per day (2% of recommended daily amount) or 170 kcal per day (7% of recommended daily amount), based on survey and manufacturer data respectively.[20] This difference could be partly due to wastage, but indicates that people most likely consume a greater volume of soft drinks than they report in surveys. According to Ng and colleagues (2012)[21], the estimated volume of SSBs purchased per person per week has more than doubled between 1975 and 2007 from 512ml to 1142ml.

One source of purchasing data in the UK is the Family Food Dataset. This survey data includes food and drinks that have been purchased by households as well as food purchased when people have eaten out. This data is available down to a region level. Based on data from the Family Food Dataset, average grams of non-milk extrinsic sugars bought were 77g per person per day in the North West, and 79g in England (3 year average of 2010-2012).[22] This is 19-20 teaspoons of sugar. Average total calories per person per day were slightly lower for the North West (2203) than for England (2241). The highest number of calories and greatest amount of sugar was in the South West, but this may relate more to affluence with families in the South East buying more food and drinks but possibly wasting more (See Figures 1 - 2). However because most SSBs have a reasonably long shelf life, wastage may be less of an issue. National data from WRAP (Waste and Resources Action Programme) for 2012 indicated that 7% of carbonated soft drinks were wasted (230,000 tonnes), with the main reason being that too much had been served.[23] The North West has a similar volume of soft drinks purchases to England, with a slightly lower volume of concentrated soft drinks purchased (Figure 3).

Figure 1. Average total kcalories purchased per person per day by region and England, based on Family Food Dataset, 3 year average of 2010-2012. Includes reported household and eating out data.

[19] British Soft Drinks Association (2012) 2012 BSDA UK Soft Drinks Report. Available at: http://www.britishsoftdrinks.com/PDF/UK%20soft%20drinks%20report%202012.pdf
[20] This section is based on a personal communication from Oliver Mytton.
[21] Ng, SW. Mhurchu, C. Jebb, S. and Popkin, B., (2012) Patterns and trends of beverage consumption among children and adults in Great Britain, 1986-2009. British Journal of Nutrition, 108(3), pp.536-551.
[22] https://www.gov.uk/government/statistical-data-sets/family-food-datasets
[23] WRAP [Waste and Resources Action Programme] (2013) Final Report: Household Food and Drink Waste in the United Kingdom 2012. http://www.wrap.org.uk/content/household-food-and-drink-waste-uk-2012

Figure 2. Average grams purchased per person per day of total sugars, and of non-milk extrinsic sugars, by region and England, based on Family Food Dataset, 3 year average of 2010-2012. Includes reported household and eating out data.

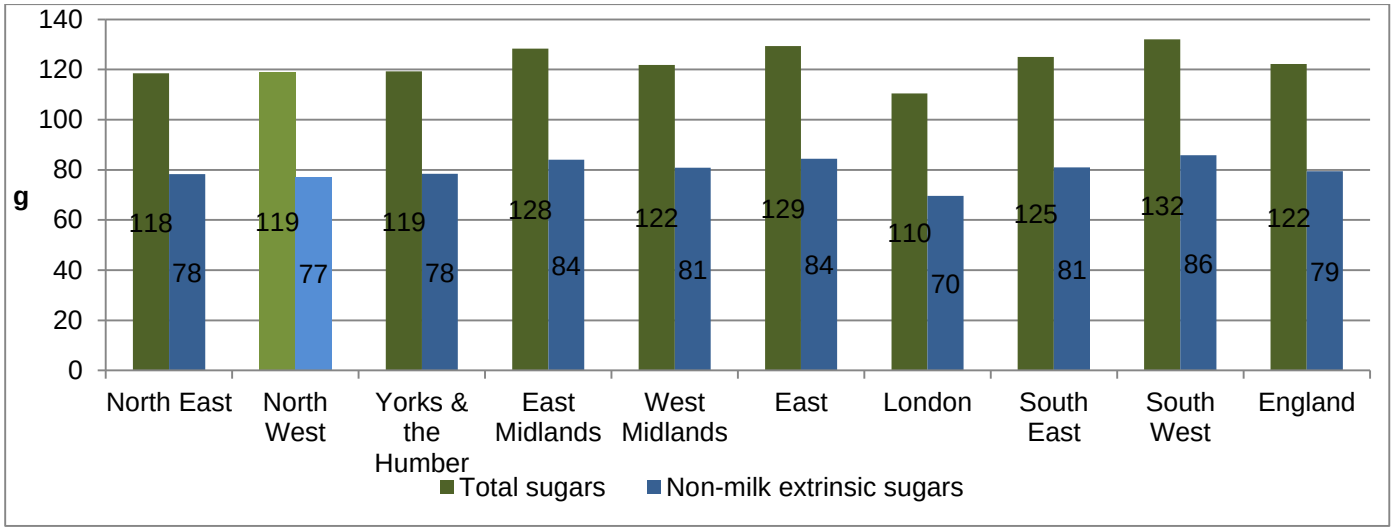
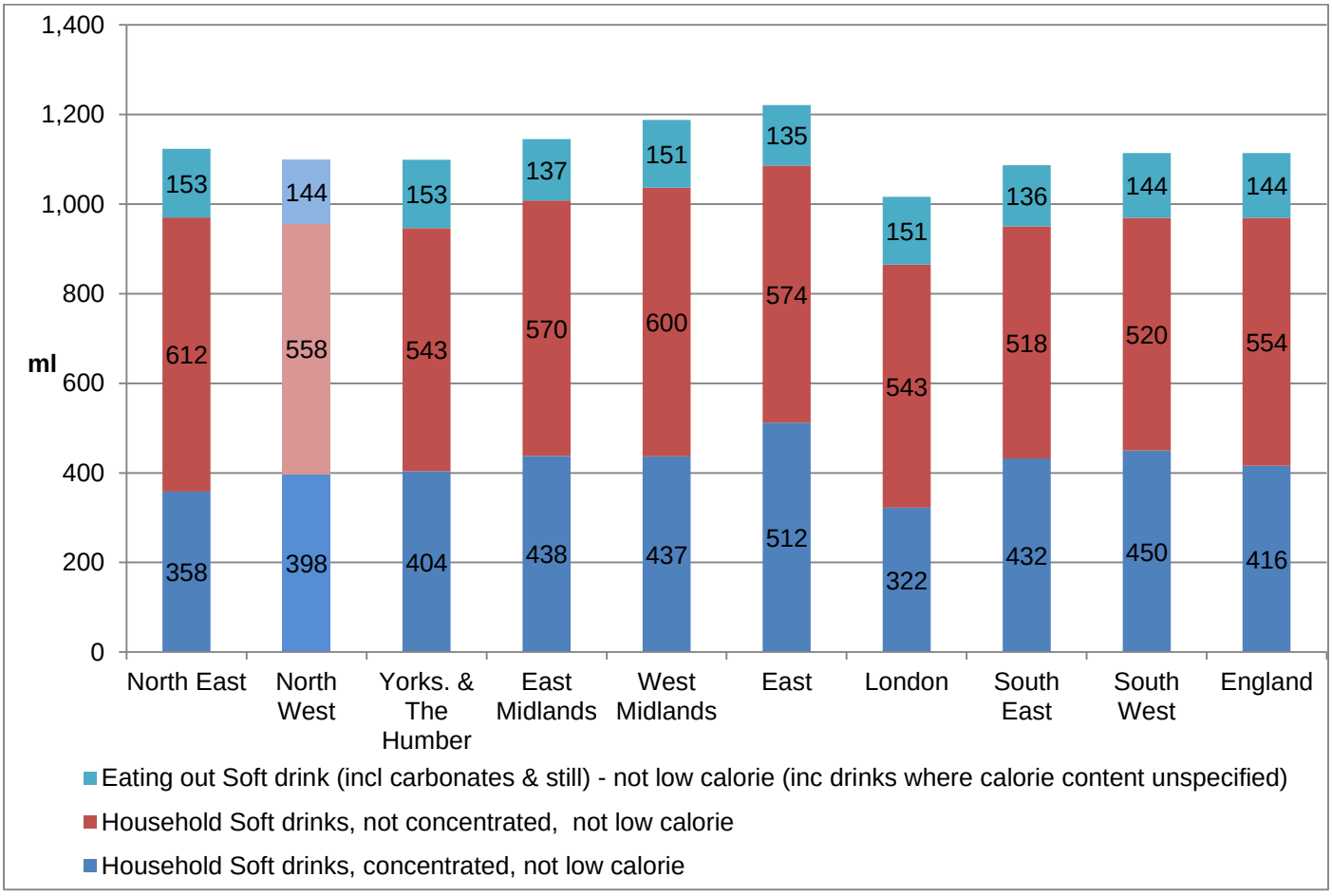


Figure 3. Average millilitres purchased per person per day of soft drinks bought when eating out, and household bought concentrated and non-concentrated soft drinks, by region and England, based on Family Food Dataset, 3 year average of 2010-2012.

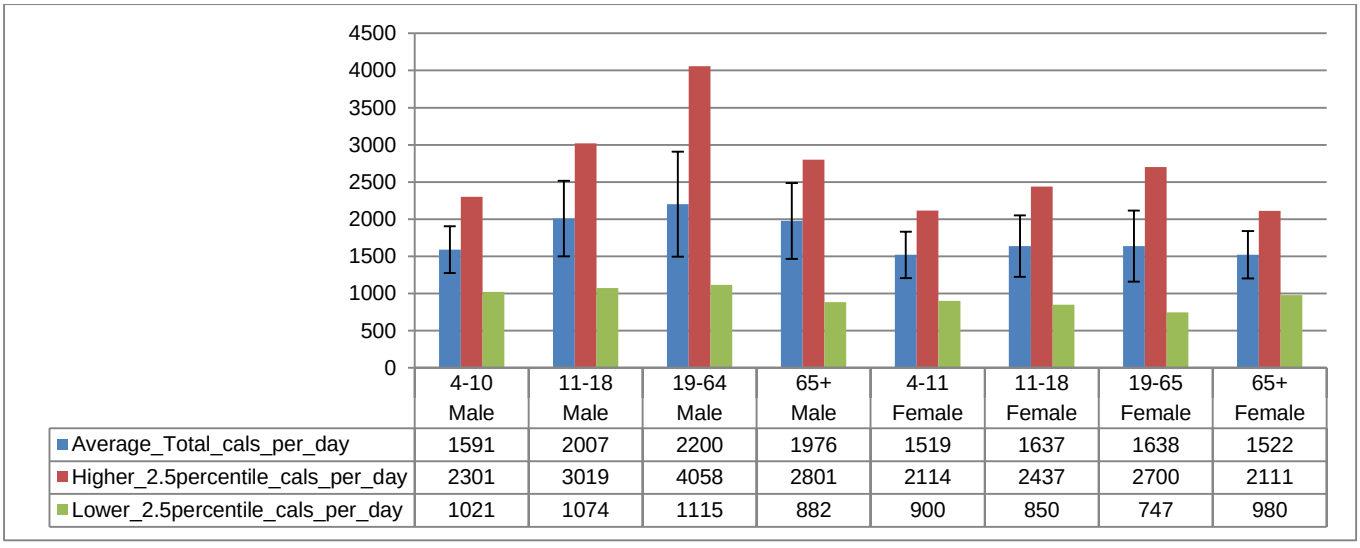


The main source we found for individual-level daily calorie intake data was the National Diet and Nutrition Survey (NDNS)[24] which has been carried out in England each year from April 2008. This also has data on the proportion of the population who consume sugary soft drinks, and the average number of grams per day consumed of soft drinks, from which we can estimate the proportion of calories from soft drinks. The data we have used is for years 1-2 of the survey, from 2008-2010.

Figure 4 shows the estimates of total calorie intake per day by gender and age group, with standard deviations, and with 2.5th percentile and 97.5th percentiles. There has been a paradoxical effect observed over the last ten years where based on surveys, average calorie reduction has fallen while obesity is increasing. Considering that 61.3% of adults are overweight or obese, the average numbers of calories per day seem lower than may be expected, given they are lower than the recommended number of calories per day for men of 2500 kcal and women of 2000 kcal to maintain a healthy weight. Even one standard deviation barely goes over the recommended number of calories. This indicates that either, the recommended number of calories per day to maintain a healthy weight are too high, or more likely, that people in the survey underestimate the number of calories they take in per day, for instance by underestimating calories from snacks or from alcoholic beverages.[25] The energy recommendations of 2000/2500 kcal are based on moderate activity, whereas many people have a low level of activity. Clearly weight is driven both by energy intake and energy output so more active people can take in more calories without putting on excess weight. Also individual metabolism varies as well. Underreporting is common in surveys like this and the NDNS has included doubly labelled water (DLW) measurements for a subset of participants to measure total energy expenditure and assess the extent of misreporting of energy intake. Results from the DLW sub-study will be included in the Year 1-4 NDNS report when it is published.[26]

In our model we have used the average number of calories per gram of SSB across all age groups in the NDNS which is 0.312 kcalories per gram (other published estimates have been slightly higher than this).

Figure 4. Average total kcalories per day, shown with standard deviation (error bars) and 2.5th and 97.5th percentile. Data for England from NDNS.



	4-10 Male	11-18 Male	19-64 Male	65+ Male	4-11 Female	11-18 Female	19-65 Female	65+ Female
Average_Total_cals_per_day	1591	2007	2200	1976	1519	1637	1638	1522
Higher_2.5percentile_cals_per_day	2301	3019	4058	2801	2114	2437	2700	2111
Lower_2.5percentile_cals_per_day	1021	1074	1115	882	900	850	747	980

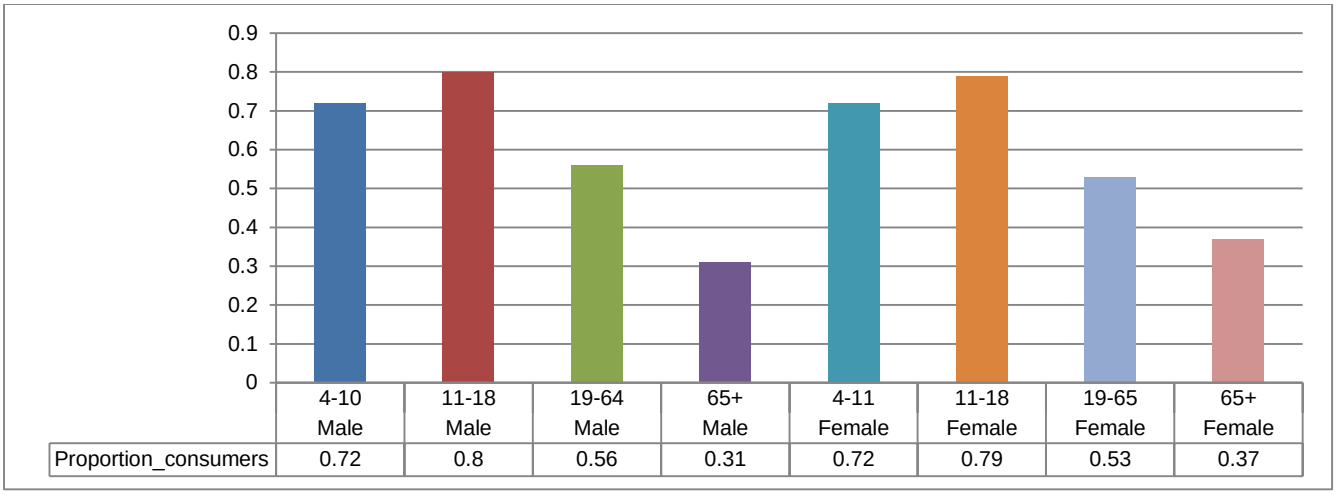
[24] National Diet and Nutrition Survey: Headline results from Years 1 and 2 (combined) of the rolling programme 2008-9 - 2009-10. Available at: https://www.gov.uk/government/publications/national-diet-and-nutrition-survey-headline-results-from-years-1-and-2-combined-of-the-rolling-programme-2008-9-2009-10

[25] Livingstone M.B. Black A. (2003) Markers of the validity of reported energy intake. Journal of Nutrition, 133: S895-S920.

[26] Personal communication from Dr Sonja Nicholson, NDNS Coordinator.

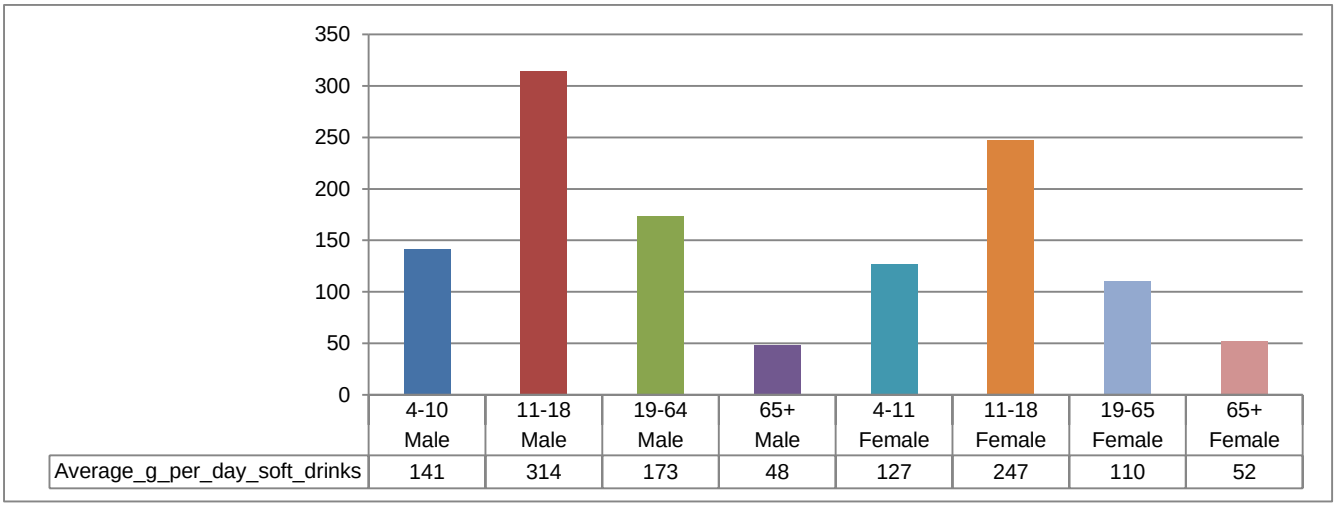
Figure 5 shows the proportion of the population who are SSB consumers (in the NDNS it refers to 'soft drinks, not low calorie' which we have taken to be equivalent to our definition of SSBs). The biggest consumers are 11-18 year olds with around 80% being consumers. Males and females have a similar probability of being SSB consumers at ages 4-19. At 19-65 men are more likely to be consumers, whereas at 65 and over, women are more likely to be consumers. There is likely to be both an age effect, where younger people are more likely to be SSB consumers, and a cohort effect, that SSBs have become cheaper, are marketed more aggressively and have become more available over time, so that people born after 1980 are more likely to be SSB consumers throughout their lives than people born before 1980. This fits in with the insight work which found that older people saw consumption of SSBs as more of a treat whereas younger people often saw it as part of their daily routine.[1] The estimated average proportion of calories per day that come from SSBs vary between 0.8% in males aged 65+ to 4.9% in males aged 11-18. As stated previously, this could be an underestimate.

igure 5. Proportion of England population who are SSB consumers. From NDNS.



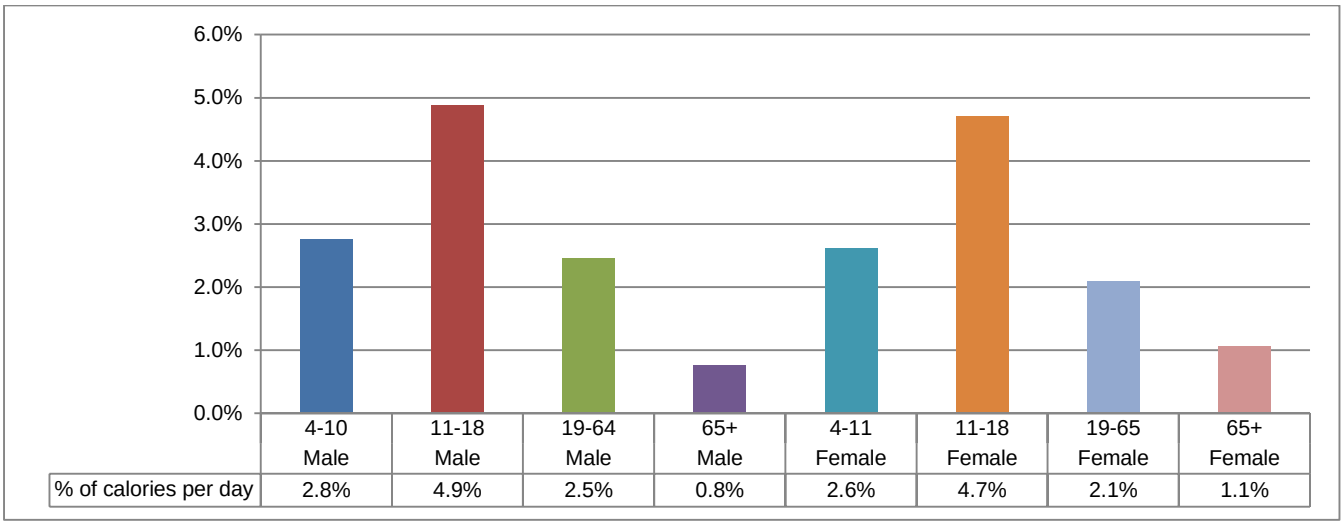
	4-10 Male	11-18 Male	19-64 Male	65+ Male	4-11 Female	11-18 Female	19-65 Female	65+ Female
Proportion_consumers	0.72	0.8	0.56	0.31	0.72	0.79	0.53	0.37

Figure 6. Average grams per day consumed of soft drinks (includes non-consumers of soft drinks). Data for England from NDNS.



	4-10 Male	11-18 Male	19-64 Male	65+ Male	4-11 Female	11-18 Female	19-65 Female	65+ Female
Average_g_per_day_soft_drinks	141	314	173	48	127	247	110	52

Figure 7. Percentage of average total calories per day from soft drinks (includes non-consumers of soft drinks). Data for England from NDNS.



	4-10 Male	11-18 Male	19-64 Male	65+ Male	4-11 Female	11-18 Female	19-65 Female	65+ Female
% of calories per day	2.8%	4.9%	2.5%	0.8%	2.6%	4.7%	2.1%	1.1%

3.2. Weight and BMI Projections

Weight and BMI projections were drawn from a paper by Wang and colleagues[27] which projected the health and economic burden of obesity trends in the UK and the US from 2010 to 2030 using microsimulation. This was based partly on the modelling done by the Foresight team (2007) and used Health Survey for England data from 1993-2008 for trends in obesity rates. After increasing for many years, the rate of increase in obesity in the UK is levelling off. [28] This paper estimates that there will be 11 million more obese adults in the UK in 2030 than in 2010. To get estimates for England, the values for the UK were multiplied by 0.838 which was England 16+ population divided by United Kingdom 16+ population for 2011. This was then weighted by the estimated number of obese adults in each local authority.

For obesity estimates at local authority level, we used the estimates of the percentage of the adult population with obesity, which were developed by the East Midlands Public Health Observatory (EMPHO) and the National Centre for Social Research (Natcen)**.** [29]This work estimates that there were nearly 10 million obese adults in England in the time period they looked at, 2006-08. These estimates are based on logistic regression modelling of Health Survey for England data for 2006-08 that have been adjusted to add up to regional averages. These are the most reliable obesity estimates available consistently at the level of granularity required and are consistent with the Wang paper in that they use Health Survey for England data. In this model the area-level characteristics associated with increased propensity for an adult to be obese were: a higher proportion of residents of Black ethnic origin; a higher proportion of residents aged 55-64; and a higher proportion of residents aged 16-74 who had no qualifications or whose highest qualification attained was Level 1. The area-level characteristics associated with decreased propensity for an adult to be obese were: a higher proportion of residents aged 16-74 who just had no qualifications; a relatively higher proportion of residents who live in council tax band H [which equates to the highest valued houses, valued at greater than £320,000 at 1991 prices]; a higher proportion of residents diagnosed with Coronary Heart Disease; and a higher proportion of residents diagnosed with lung cancer. The alternative

[27] Wang YC, McPherson K, Marsh T, Gortmaker SL, Brown M (2011). Health and economic burden of the projected obesity trends in the USA and the UK. *Lancet*, vol 378: pp 815-25.
[28] Sperrin M, et al. Slowing down of adult body mass index trend increases in England: a latent class analysis of cross-sectional surveys (1992-2010). International Journal of Obesity. Published online September 2 2013
[29] EMPHO (2011) Percentage of the adult population with obesity, modelled estimates for 2010 based on Health Survey for England data for 2006-08. http://www.noo.org.uk/data_sources/adult/model_based_estimates

sources of obesity prevalence data would be to create a de novo model based on population parameters, to use other modelled estimates, or using GP Quality and Outcomes Framework data, but this is not collected for all GP practices and measurement rates vary greatly between areas.

3.3. Price Elasticity of Demand

For price elasticity, we have used data from Ng & colleagues' paper which estimated the resultant reduction in number of millilitres of SSBs consumption from a 10% or 20% price increase, which we have then converted to kcalories using the average number of kcalories per ml of SSB from the NDNS. Ng & colleagues' paper estimated that a 10% price increase would reduce SSB consumption by 4.6% and a 20% price increase would reduce consumption by 9.1% (a price elasticity of -0.46). The cross price elasticity of low calorie soft drinks was very small, at -0.026 which indicates there is little substitution of high calorie drinks with low calorie drinks when prices increase so we have not factored this into the model, and most low calorie drinks contain almost no calories anyway. We have applied the same price elasticity across age and gender groups, although it is likely that there are some differences in this in reality, for instance in the insight work it was suggested that soft drinks prices varied a lot at the individual item level, and that young people were used to paying whatever price was charged for their soft drinks.1

The recent study by Briggs and colleagues4 included price elasticity of demand estimates by tertiles of income groups which could potentially be incorporated into this model in future if we had corresponding data for North West local authorities (or could use income deprivation index or similar as a proxy). The Briggs paper assumes a higher price elasticity than the Ng paper, i.e. that consumers will be more sensitive to price. The modelled price elasticity in the Briggs paper was around twice that found in the Ng paper, at -0.921 for concentrated SSBs and -0.903 for non-concentrated. However in the Briggs paper they also assume a higher cross price elasticity value, that people will consume other calorific drinks instead of SSBs and so will substitute more of the calories from lower SSB consumption with other drinks, particularly from milk. The Briggs paper uses the SSB consumption data rather than the purchasing data and uses an almost ideal demand system model, where a reduction in consumption of one drink product is always accompanied by an increase in consumption of another drink product. This may or may not accurately fit the profile of SSB consumption where drinks may often be purchased as impulsive buys, i.e. in an impromptu fashion. There is also the issue of 'meal deals' and other promotions where SSBs are included as options in other purchases where the relationship between a duty and the final price will be more complex. In the insight work, an example was given of where someone orders a pizza and gets a free bottle of Coca-Cola.

For our model we have used a low estimate of the average grams per day of soft drinks consumed from the NDNS, and a high estimate which has been inflated by a factor of 3.1 based on the manufacturer data for soft drink sales. This is still not the highest possible estimate, as we have used the lower price elasticity of demand estimates from the Ng paper. However once the compensatory effects of cross price elasticity are taken into account, the figures from the Briggs paper are closer to the low scenario, with an average change in calorie consumption of 4.0 kcalories per person per day. The high and low scenarios are our judgment of a rational high and low scenario rather than the extreme best or worst case scenarios. There is some uncertainty and lack of evidence around several of the parameters in the model.

Table 1. Average consumption per day of SSBs and impact of a 20% duty on calories (low and high estimates), data by gender and age group.

Gender	Age group	Average g per day soft drinks from NDNS	Kcals per day soft drinks all (low estimate based on NDNS)	kcals per day increased by factor of 3.1 (478/156ml) based on manufacturer data (high estimate)	Reduction in kcals per day from 20% duty resulting in 9.1% decrease in consumption	
					Low estimate (NDNS)	High estimate (Manufacturer data)
Male	4-10	141	44	136	4.00	12.41
Male	11-18	314	98	304	8.92	27.64
Male	19-64	173	54	167	4.91	15.23
Male	65+	48	15	46	1.36	4.22
Female	4-11	127	40	123	3.61	11.18
Female	11-19	247	77	239	7.01	21.74
Female	19-65	110	34	106	3.12	9.68
Female	65+	52	16	50	1.48	4.58

3.4. Impact on diseases

The paper by Wang and colleagues modelled the impact on diabetes, CHD & stroke, cancer, and change in QALYs[30] resulting from a 20 kcalorie a day reduction in consumption, maintained over 3 years. We have scaled this in a linear way, so for instance looking at Trafford if a 20% duty produced a total reduction of 4.0 kcalories per day (low estimate) or 12.3 kcalories per day (high estimate) across the population, then the change will be between 4.0/20 and 12.3/20 times the change that would be predicted based on the whole 20 kcalorie per day reduction. Other published resources have assumed this linear relationship between calories, weight, obesity rates and obesity-related outcomes.

Table 2. Outcomes associated with obesity scenarios, from Wang et al. Change in disease cases (incidence) and QALYs, 2010-2030, United Kingdom.

Disease	**Scenario 1 - recent trend**	**Scenario 2 1% reduction in BMI for every adult at baseline - needs average net reduction of 20kcal per person per day**	**Scenario 3 if obesity rates had remained at 1990 levels**
Change in Diabetes cases	545000	-179000	-897000
Change in CHD and Stroke cases	331000	-122000	-634000
Change in Cancer cases	87000	-32000	-177000
QALYs gained or lost	-2219000	3011000	7073000

The paper by Wang and colleagues included disease and QALY outcomes but not change in numbers of obese adults, so for this we applied a similar process to the modelled reduction in numbers of obese adults from the paper by Briggs and colleagues; they estimate a reduction in obesity of 151,500 adults in England.

[30] QALYs are quality adjusted life years, which are a summary measure taking into account longevity (length of life) and health-related quality of life. One QALY is the equivalent of one year of perfect health. If an intervention improves health or quality of life, then the QALYs gained can be modelled.

We applied this number by local authority apportioned by the estimates of the percentage of the adult population with obesity, which were developed by the East Midlands Region Public Health Observatory**.** The paper by Wang and colleagues was a model of change in obesity-related outcomes over 20 years and had a time series approach which took into account population change. The number of older people is increasing, and older people are more likely to be obese, so this population change is a driver of obesity independent of other risk factors. The Briggs model used a cross-sectional approach with a constant population, so did not take into account the change in population structure over time.

We have not looked at other outcomes such as dental caries. It is known that sugary drinks are cariogenic, but the relationship between SSB consumption and caries is not linear as it depends on frequency as well as volume of SSBs consumed, and will be mediated by access to flouride which prevents caries.[31] There is evidence that both high calorie and low calorie drinks can damage teeth through acid erosion as well. We have not looked at change in bone health either; it is known that obesity is a risk factor for osteoporosis.

3.5. Disease Cost data

Table 3 shows the data sources for the annual cost of disease used in the model.

Table 3. Annual cost of diseases used in model.

	Diabetes	***CHD and Stroke***	***Cancer***
Average cost per year of treatment	£1,371	£4,614	£8,808
Notes	Average healthcare cost of control group (usual treatment for type 2 diabetes).	Hospital cost of CVD event	Average cost per patient per year for bowel cancer
Source	Farmer AJ, Wade AN, French DP, Simon J, Yudkin P, Gray A, et al. (2009) Blood glucose self-monitoring in type 2 diabetes: A randomised controlled trial. Health Technol Assess 13(15).	NICE (2010) National costing report: Prevention of cardiovascular disease. London, England: National Institute for Health and Clinical Excellence.	Trueman P, Chilcott J, Tappenden P, Lowson K, Pilgrim H, Bending M. (2007) Bowel cancer services: Costs and benefits. Report to the Department of Health. York and School of Health and Related Research (University of Sheffield); 2007.

[31] Marshall TA. (2013) JADA Continuing Education: Preventing dental caries associated with sugar-sweetened beverages. JADA 144(10): 1148-1152

3.6. Summary of Model Parameters

Table 4 shows a summary of the model parameters that determine whether an SSB duty would be successful in reducing obesity-related diseases.

Table 4. Parameters that would impact the effectiveness of a SSB duty in reducing obesity rates, shown with rational high and low values for each parameter.

Parameter	Low value	High value	Low value - data source	High value - data source	Impact on obesity
SSB Consumption	123ml/day	478ml/day	NDNS	Manufacturer data	If SSB consumption is higher as in sales data, then duty will have a bigger effect on obesity rate.
Price Elasticity of Demand	-0.46	-0.92	Ng et al (2012)	Briggs et al (2013)	If price elasticity is higher as in paper by Briggs (2013) then consumers will be more sensitive to price and SSB duty will have a bigger effect.
Cross substitution of products	0	0.154		Briggs et al (2013) [highest is for CPE for SSBs non-conc. and tea & coffee)	If individuals swap to cheaper products rather than reducing consumption then an SSB duty may have a smaller effect or no effect.
Substitution of calories	0	3.55kcal		Briggs (2013) net change in kcal per day from non-SSBs. Highest individual increase in calories is for milk	If individuals substitute more calories from other foods or drinks, then SSB duty may have a smaller effect, however most evidence suggests substitution is low for SSBs.
Obesity Rates	22.70%	25.60%	England modelled obesity estimates (APHO 2011)	England modelled obesity estimates (APHO 2011)	If there are fewer obese people in the population than the evidence suggests, then an SSB duty may have a slightly smaller effect as fewer people are being pushed down over the threshold from obese to overweight.
Change in obesity rates over time	Increase 2010-2030; 35% in women, 58% in men (UK)	Increase 2010-2030; 65% in women, 85% in men (UK)	Wang et al (2011)	Wang et al (2011)	If obesity is levelling out then projected future obesity rates may be lower, but the impact of the SSB duty should still be similar.
Effect of SSB consumption on total energy balance	0	Unknown			If SSB calories do not make as big a difference to weight, or if people compensate by becoming slightly less active then the effect on obesity and outcomes may be smaller than predicted.
Additional effect of SSB duty on public opinion / psychology /media	0	Unknown			If an SSB duty has a lot of media coverage it might have a bigger than anticipated effect in changing people's behaviour as they realise how harmful SSBs are.
Pass-on rate (the amount of a duty that is passed on to consumers)	0%	100%		Briggs et al (2013)	If manufacturers or vendors absorb all or some of the cost of the SSB duty rather than passing it onto the consumer, then the SSB duty will not reduce consumption by as much as predicted.

4. Results

We modelled the impact of a 20% duty on SSBs based on population outcomes over the 20 years from 2010-2030 and calculated an average per year. In reality the outcomes would most likely take time to be observed as SSB consumption is highest in young people who may still be 20-30 years away from starting to have obesity-related diseases, although a study has found that high SSB consumers already have higher prevalence of cardiovascular risk factors at 17 years old. [32] We modelled a rational low and high scenario based on the NDNS data and the manufacturer data. Table 5 shows the estimates of numbers of obese adults for each Local Authority in the North West and the low and high estimates for a reduction in calories consumed as a result of an SSB duty. The overall impact is a reduction of between 3.3 and 10.2 kcalories per person per day across the North West. The UK national target for reduction in calories is for a 100 kcal reduction per person per day, so this reduction in SSB consumption would represent 3% - 10% of this reduction. Looking across the North West, the biggest change in calories is for Manchester (high scenario 12.8 kcalories per person per day) while the smallest change is for South Lakeland (high scenario 11.4 kcalories per person per day). This difference is driven by the age structure of the population. Based on the high scenario (which is based on manufacturer sales data), a duty would result in 592 fewer diabetes cases, 404 fewer stroke and coronary heart disease cases, 106 fewer cancer cases, and 9,964 Quality Adjusted Life Years (QALYs) gained per year across the North West. The local authority with the largest number of QALYs gained was Liverpool. The National Institute for Health and Care Excellence (NICE) consider public health interventions to be cost effective if the incremental cost effectiveness ratio (ICER), or incremental cost per QALY gained when compared to the next best alternative intervention, is less than £20,000. So if the QALYs gained per year for an SSB duty were valued at £20,000 per QALY, the total value of these QALYs, or total net benefit, would be £199million per year across the North West. This is not a cashable benefit; rather it is based on society's willingness to pay for the healthcare gains that would result from an SSB duty.

There would be additional cash savings from the reduction in healthcare costs for treating obesity related diseases of around £3.9million for the North West (Table 8). In addition, the report by Briggs and colleagues predicted that a 20% duty would generate £276m in revenue in the UK which would equate to roughly £30m a year in the North West. Or the Sustain report estimated that a 20p per litre duty on SSBs would raise £1billion per annum in the UK, which would equate to around £109million for the North West.

[32] Ambrosini GL. Oddy WH. Huang RC. et al. (2013) Prospective associations between sugar-sweetened beverage intakes and cardiometabolic risk factors in adolescents. American Journal of Clinical Nutrition 05/2013

Table 5. Estimated numbers of obese adults and estimated calorie per person reduction from a 20% SSB duty, North West local authorities.

					Impact of 20% SSB duty	
Area Code	*Area Name*	*Estimated N of obese adults 2010 based on Health Survey for England data 2006-08.*	*Proportion of total obese adults in England*	*Proportion of total obese adults in the North West*	*Total average reduction in kcalories per person per day-low scenario*	*Total average reduction in kcalories per person per day-high scenario*
E06000006	Halton UA	24,690	0.2%	1.9%	4.0	12.3
E06000007	Warrington UA	36,086	0.4%	2.8%	4.0	12.3
E06000008	Blackburn with Darwen UA	26,246	0.3%	2.0%	4.1	12.7
E06000009	Blackpool UA	30,031	0.3%	2.3%	3.9	11.9
E06000049	Cheshire East UA	63,374	0.6%	4.9%	3.8	11.9
E06000050	Cheshire West and Chester UA	60,710	0.6%	4.7%	3.8	11.9
E07000026	Allerdale CD	19,332	0.2%	1.5%	3.8	11.8
E07000027	Barrow-in-Furness CD	15,212	0.2%	1.2%	3.9	12.0
E07000028	Carlisle CD	20,831	0.2%	1.6%	3.8	11.9
E07000029	Copeland CD	14,871	0.1%	1.1%	3.8	11.9
E07000030	Eden CD	10,254	0.1%	0.8%	3.8	11.6
E07000031	South Lakeland CD	17,977	0.2%	1.4%	3.7	11.4
E07000117	Burnley CD	17,068	0.2%	1.3%	3.9	12.2
E07000118	Chorley CD	19,631	0.2%	1.5%	3.9	12.1
E07000119	Fylde CD	13,463	0.1%	1.0%	3.7	11.4
E07000120	Hyndburn CD	16,139	0.2%	1.2%	4.0	12.3
E07000121	Lancaster CD	24,935	0.2%	1.9%	3.9	12.0
E07000122	Pendle CD	17,401	0.2%	1.3%	3.9	12.2
E07000123	Preston CD	22,122	0.2%	1.7%	4.0	12.4
E07000124	Ribble Valley CD	10,136	0.1%	0.8%	3.9	12.0
E07000125	Rossendale CD	12,520	0.1%	1.0%	4.0	12.3
E07000126	South Ribble CD	18,561	0.2%	1.4%	3.9	12.0
E07000127	West Lancashire CD	20,172	0.2%	1.6%	3.9	12.0
E07000128	Wyre CD	21,111	0.2%	1.6%	3.7	11.4
E08000001	Bolton MCD	48,696	0.5%	3.8%	4.0	12.4
E08000002	Bury MCD	33,155	0.3%	2.6%	3.9	12.2
E08000003	Manchester MCD	78,842	0.8%	6.1%	4.1	12.8
E08000004	Oldham MCD	43,977	0.4%	3.4%	4.0	12.5
E08000005	Rochdale MCD	40,437	0.4%	3.1%	4.0	12.5
E08000006	Salford MCD	42,009	0.4%	3.2%	4.0	12.4
E08000007	Stockport MCD	50,168	0.5%	3.9%	3.9	12.0
E08000008	Tameside MCD	45,700	0.5%	3.5%	4.0	12.3
E08000009	Trafford MCD	36,658	0.4%	2.8%	4.0	12.3
E08000010	Wigan MCD	63,819	0.6%	4.9%	3.9	12.2
E08000011	Knowsley MCD	30,646	0.3%	2.4%	4.0	12.3
E08000012	Liverpool MCD	82,086	0.8%	6.3%	4.0	12.3
E08000013	St Helens MCD	35,983	0.4%	2.8%	3.9	12.0
E08000014	Sefton MCD	53,994	0.5%	4.2%	3.8	11.8
E08000015	Wirral MCD	57,985	0.6%	4.5%	3.9	11.9
	North West total	**1,297,027**	**13.0%**	**100.0%**	**3.3**	**10.2**

Table 6. Average change in cases per year and QALYs gained from a 20% SSB duty, low scenario.

Area Code	*Area Name*	*Change in diabetes cases*	*Change in CHD and Stroke cases*	*Change in cancer cases*	*QALYs gained or lost*	*Value of QALYs at £10k per QALY*	*Value of QALYs at £20k per QALY*
E06000006	Halton UA	-3.7	-2.5	-0.7	62.0	£619,730	£1,239,460
E06000007	Warrington UA	-5.4	-3.7	-1.0	90.2	£902,467	£1,804,934
E06000008	Blackburn with Darwen UA	-4.0	-2.8	-0.7	68.1	£680,895	£1,361,789
E06000009	Blackpool UA	-4.3	-3.0	-0.8	73.1	£731,243	£1,462,485
E06000049	Cheshire East UA	-9.1	-6.2	-1.6	153.6	£1,536,375	£3,072,750
E06000050	Cheshire West and Chester	-8.8	-6.0	-1.6	147.6	£1,475,768	£2,951,537
E07000026	Allerdale CD	-2.8	-1.9	-0.5	46.4	£464,072	£928,144
E07000027	Barrow-in-Furness CD	-2.2	-1.5	-0.4	37.3	£372,576	£745,152
E07000028	Carlisle CD	-3.0	-2.0	-0.5	50.4	£504,364	£1,008,728
E07000029	Copeland CD	-2.1	-1.5	-0.4	36.2	£361,543	£723,086
E07000030	Eden CD	-1.4	-1.0	-0.3	24.3	£243,388	£486,776
E07000031	South Lakeland CD	-2.5	-1.7	-0.4	41.8	£417,595	£835,190
E07000117	Burnley CD	-2.5	-1.7	-0.5	42.4	£424,006	£848,011
E07000118	Chorley CD	-2.9	-2.0	-0.5	48.6	£485,529	£971,058
E07000119	Fylde CD	-1.9	-1.3	-0.3	31.3	£313,014	£626,029
E07000120	Hyndburn CD	-2.4	-1.6	-0.4	40.5	£404,864	£809,728
E07000121	Lancaster CD	-3.6	-2.5	-0.6	60.9	£608,792	£1,217,583
E07000122	Pendle CD	-2.6	-1.8	-0.5	43.3	£433,061	£866,121
E07000123	Preston CD	-3.3	-2.3	-0.6	56.1	£561,000	£1,122,000
E07000124	Ribble Valley CD	-1.5	-1.0	-0.3	24.8	£248,037	£496,075
E07000125	Rossendale CD	-1.9	-1.3	-0.3	31.3	£313,126	£626,252
E07000126	South Ribble CD	-2.7	-1.8	-0.5	45.4	£454,250	£908,501
E07000127	West Lancashire CD	-2.9	-2.0	-0.5	49.2	£491,659	£983,319
E07000128	Wyre CD	-2.9	-2.0	-0.5	49.1	£491,091	£982,182
E08000001	Bolton MCD	-7.3	-5.0	-1.3	122.9	£1,229,343	£2,458,686
E08000002	Bury MCD	-4.9	-3.4	-0.9	82.7	£826,923	£1,653,846
E08000003	Manchester MCD	-12.2	-8.3	-2.2	205.3	£2,052,829	£4,105,659
E08000004	Oldham MCD	-6.7	-4.5	-1.2	112.0	£1,119,545	£2,239,089
E08000005	Rochdale MCD	-6.1	-4.2	-1.1	102.6	£1,026,407	£2,052,814
E08000006	Salford MCD	-6.3	-4.3	-1.1	106.0	£1,059,607	£2,119,214
E08000007	Stockport MCD	-7.3	-5.0	-1.3	123.0	£1,230,205	£2,460,409
E08000008	Tameside MCD	-6.8	-4.6	-1.2	114.1	£1,141,153	£2,282,305
E08000009	Trafford MCD	-5.5	-3.7	-1.0	91.7	£917,094	£1,834,188
E08000010	Wigan MCD	-9.4	-6.4	-1.7	158.4	£1,584,228	£3,168,457
E08000011	Knowsley MCD	-4.6	-3.1	-0.8	76.6	£766,388	£1,532,775
E08000012	Liverpool MCD	-12.3	-8.4	-2.2	206.2	£2,062,476	£4,124,951
E08000013	St Helens MCD	-5.2	-3.6	-0.9	88.3	£882,613	£1,765,226
E08000014	Sefton MCD	-7.7	-5.2	-1.4	129.4	£1,294,289	£2,588,577
E08000015	Wirral MCD	-8.4	-5.7	-1.5	141.1	£1,410,884	£2,821,768
	North West total	**-191.1**	**-130.2**	**-34.2**	**3214.2**	**£32,142,427**	**£64,284,854**

Table 7. Average change in cases per year and QALYs gained, high scenario.

Area Code	*Area Name*	*Change in diabetes cases*	*Change in CHD and Stroke cases*	*Change in cancer cases*	*QALYs gained or lost*	*Value of QALYs at £10k per QALY*	*Value of QALYs at £20k per QALY*
E06000006	Halton UA	-11.4	-7.8	-2.0	192.1	£1,921,162	£3,842,325
E06000007	Warrington UA	-16.6	-11.3	-3.0	279.8	£2,797,647	£5,595,295
E06000008	Blackburn with Darwen UA	-12.5	-8.6	-2.2	211.1	£2,110,774	£4,221,547
E06000009	Blackpool UA	-13.5	-9.2	-2.4	226.7	£2,266,852	£4,533,705
E06000049	Cheshire East UA	-28.3	-19.3	-5.1	476.3	£4,762,763	£9,525,526
E06000050	Cheshire West and Chester UA	-27.2	-18.5	-4.9	457.5	£4,574,882	£9,149,764
E07000026	Allerdale CD	-8.6	-5.8	-1.5	143.9	£1,438,624	£2,877,247
E07000027	Barrow-in-Furness CD	-6.9	-4.7	-1.2	115.5	£1,154,986	£2,309,971
E07000028	Carlisle CD	-9.3	-6.3	-1.7	156.4	£1,563,528	£3,127,056
E07000029	Copeland CD	-6.7	-4.5	-1.2	112.1	£1,120,783	£2,241,567
E07000030	Eden CD	-4.5	-3.1	-0.8	75.5	£754,502	£1,509,004
E07000031	South Lakeland CD	-7.7	-5.2	-1.4	129.5	£1,294,544	£2,589,089
E07000117	Burnley CD	-7.8	-5.3	-1.4	131.4	£1,314,418	£2,628,836
E07000118	Chorley CD	-8.9	-6.1	-1.6	150.5	£1,505,140	£3,010,280
E07000119	Fylde CD	-5.8	-3.9	-1.0	97.0	£970,345	£1,940,689
E07000120	Hyndburn CD	-7.5	-5.1	-1.3	125.5	£1,255,078	£2,510,156
E07000121	Lancaster CD	-11.2	-7.6	-2.0	188.7	£1,887,254	£3,774,509
E07000122	Pendle CD	-8.0	-5.4	-1.4	134.2	£1,342,488	£2,684,976
E07000123	Preston CD	-10.3	-7.0	-1.8	173.9	£1,739,101	£3,478,201
E07000124	Ribble Valley CD	-4.6	-3.1	-0.8	76.9	£768,916	£1,537,832
E07000125	Rossendale CD	-5.8	-3.9	-1.0	97.1	£970,690	£1,941,381
E07000126	South Ribble CD	-8.4	-5.7	-1.5	140.8	£1,408,176	£2,816,352
E07000127	West Lancashire CD	-9.1	-6.2	-1.6	152.4	£1,524,144	£3,048,287
E07000128	Wyre CD	-9.1	-6.2	-1.6	152.2	£1,522,382	£3,044,763
E08000001	Bolton MCD	-22.7	-15.4	-4.1	381.1	£3,810,963	£7,621,925
E08000002	Bury MCD	-15.2	-10.4	-2.7	256.3	£2,563,462	£5,126,923
E08000003	Manchester MCD	-37.8	-25.8	-6.8	636.4	£6,363,771	£12,727,542
E08000004	Oldham MCD	-20.6	-14.1	-3.7	347.1	£3,470,588	£6,941,177
E08000005	Rochdale MCD	-18.9	-12.9	-3.4	318.2	£3,181,861	£6,363,722
E08000006	Salford MCD	-19.5	-13.3	-3.5	328.5	£3,284,782	£6,569,564
E08000007	Stockport MCD	-22.7	-15.5	-4.1	381.4	£3,813,634	£7,627,268
E08000008	Tameside MCD	-21.0	-14.3	-3.8	353.8	£3,537,573	£7,075,146
E08000009	Trafford MCD	-16.9	-11.5	-3.0	284.3	£2,842,991	£5,685,982
E08000010	Wigan MCD	-29.2	-19.9	-5.2	491.1	£4,911,108	£9,822,217
E08000011	Knowsley MCD	-14.1	-9.6	-2.5	237.6	£2,375,801	£4,751,603
E08000012	Liverpool MCD	-38.0	-25.9	-6.8	639.4	£6,393,674	£12,787,349
E08000013	St Helens MCD	-16.3	-11.1	-2.9	273.6	£2,736,100	£5,472,200
E08000014	Sefton MCD	-23.9	-16.3	-4.3	401.2	£4,012,295	£8,024,589
E08000015	Wirral MCD	-26.0	-17.7	-4.6	437.4	£4,373,741	£8,747,481
	North West total	**-592.4**	**-403.7**	**-105.9**	**9964.2**	**£99,641,524**	**£199,283,048**

Table 8 shows an estimate of healthcare cost savings per year based on high scenario. The biggest cost savings are through reduced spend on CHD and stroke events.

Table 8. Healthcare cost savings per annum, high scenario.

Area Code	Area Name	Diabetes	CHD & Stroke	Cancer	Total cost savings
E06000006	Halton UA	£15,658	£35,916	£17,984	£69,558
E06000007	Warrington UA	£22,802	£52,302	£26,188	£101,293
E06000008	Blackburn with Darwen UA	£17,204	£39,461	£19,759	£76,423
E06000009	Blackpool UA	£18,476	£42,379	£21,220	£82,074
E06000049	Cheshire East UA	£38,818	£89,040	£44,584	£172,442
E06000050	Cheshire West and Chester UA	£37,287	£85,528	£42,825	£165,640
E07000026	Allerdale CD	£11,725	£26,895	£13,467	£52,087
E07000027	Barrow-in-Furness CD	£9,414	£21,593	£10,812	£41,818
E07000028	Carlisle CD	£12,743	£29,230	£14,636	£56,610
E07000029	Copeland CD	£9,135	£20,953	£10,492	£40,579
E07000030	Eden CD	£6,150	£14,105	£7,063	£27,318
E07000031	South Lakeland CD	£10,551	£24,202	£12,118	£46,871
E07000117	Burnley CD	£10,713	£24,573	£12,304	£47,590
E07000118	Chorley CD	£12,268	£28,139	£14,089	£54,496
E07000119	Fylde CD	£7,909	£18,141	£9,083	£35,133
E07000120	Hyndburn CD	£10,229	£23,464	£11,749	£45,442
E07000121	Lancaster CD	£15,382	£35,282	£17,666	£68,331
E07000122	Pendle CD	£10,942	£25,098	£12,567	£48,607
E07000123	Preston CD	£14,174	£32,513	£16,280	£62,966
E07000124	Ribble Valley CD	£6,267	£14,375	£7,198	£27,840
E07000125	Rossendale CD	£7,912	£18,147	£9,087	£35,145
E07000126	South Ribble CD	£11,477	£26,326	£13,182	£50,985
E07000127	West Lancashire CD	£12,422	£28,494	£14,267	£55,184
E07000128	Wyre CD	£12,408	£28,461	£14,251	£55,120
E08000001	Bolton MCD	£31,061	£71,246	£35,674	£137,981
E08000002	Bury MCD	£20,893	£47,924	£23,996	£92,814
E08000003	Manchester MCD	£51,867	£118,971	£59,570	£230,409
E08000004	Oldham MCD	£28,287	£64,883	£32,488	£125,657
E08000005	Rochdale MCD	£25,933	£59,485	£29,785	£115,204
E08000006	Salford MCD	£26,772	£61,409	£30,748	£118,930
E08000007	Stockport MCD	£31,083	£71,296	£35,699	£138,078
E08000008	Tameside MCD	£28,833	£66,135	£33,115	£128,083
E08000009	Trafford MCD	£23,172	£53,150	£26,613	£102,934
E08000010	Wigan MCD	£40,028	£91,813	£45,972	£177,813
E08000011	Knowsley MCD	£19,364	£44,416	£22,240	£86,019
E08000012	Liverpool MCD	£52,111	£119,530	£59,850	£231,492
E08000013	St Helens MCD	£22,300	£51,152	£25,612	£99,064
E08000014	Sefton MCD	£32,702	£75,010	£37,559	£145,271
E08000015	Wirral MCD	£35,648	£81,767	£40,942	£158,357
	North West total	£1,113,416	£1,862,803	£932,732	£3,908,952

We also applied the estimates of change in obese adults from the paper by Briggs (2013) to the North West population. From this we estimated that a 20% SSB duty would reduce the number of obese adults in the North West by 19,683 people, a 1.5% reduction.

Table 9. Average change in numbers of obese adults after 20% SSB duty. Based on data from cross sectional model for the UK by Briggs et al. (2013)

		Before SSB duty	*After SSB Duty*	*Change in number of obese adults*	*Before SSB duty*	*After SSB Duty*	*% change in N obese adults*
Area Code	***Area Name***	***N obese adults***			***% obese adults***		
E06000006	Halton UA	24,690	24,315	-375	25.9%	25.5%	-1.5%
E06000007	Warrington UA	36,086	35,538	-548	22.9%	22.6%	-1.4%
E06000008	Blackburn with Darwen UA	26,246	25,847	-398	24.6%	24.2%	-1.6%
E06000009	Blackpool UA	30,031	29,575	-456	25.8%	25.4%	-1.5%
E06000049	Cheshire East UA	63,374	62,412	-962	21.6%	21.2%	-1.7%
E06000050	Cheshire West and Chester UA	60,710	59,789	-921	22.7%	22.3%	-1.6%
E07000026	Allerdale CD	19,332	19,039	-293	24.8%	24.5%	-1.4%
E07000027	Barrow-in-Furness CD	15,212	14,981	-231	26.1%	25.7%	-1.5%
E07000028	Carlisle CD	20,831	20,515	-316	24.3%	24.0%	-1.4%
E07000029	Copeland CD	14,871	14,645	-226	25.7%	25.3%	-1.5%
E07000030	Eden CD	10,254	10,098	-156	23.8%	23.5%	-1.5%
E07000031	South Lakeland CD	17,977	17,704	-273	20.5%	20.2%	-1.6%
E07000117	Burnley CD	17,068	16,809	-259	24.5%	24.1%	-1.5%
E07000118	Chorley CD	19,631	19,333	-298	23.1%	22.8%	-1.5%
E07000119	Fylde CD	13,463	13,259	-204	20.9%	20.6%	-1.5%
E07000120	Hyndburn CD	16,139	15,895	-245	25.1%	24.7%	-1.6%
E07000121	Lancaster CD	24,935	24,556	-378	20.9%	20.6%	-1.4%
E07000122	Pendle CD	17,401	17,137	-264	24.3%	24.0%	-1.3%
E07000123	Preston CD	22,122	21,786	-336	20.8%	20.5%	-1.5%
E07000124	Ribble Valley CD	10,136	9,982	-154	21.4%	21.1%	-1.6%
E07000125	Rossendale CD	12,520	12,330	-190	23.5%	23.1%	-1.6%
E07000126	South Ribble CD	18,561	18,279	-282	21.3%	21.0%	-1.4%
E07000127	West Lancashire CD	20,172	19,866	-306	22.7%	22.3%	-1.6%
E07000128	Wyre CD	21,111	20,790	-320	22.9%	22.5%	-1.6%
E08000001	Bolton MCD	48,696	47,957	-739	23.4%	23.1%	-1.3%
E08000002	Bury MCD	33,155	32,652	-503	22.7%	22.3%	-1.7%
E08000003	Manchester MCD	78,842	77,645	-1196	21.1%	20.8%	-1.5%
E08000004	Oldham MCD	43,977	43,310	-667	25.7%	25.3%	-1.4%
E08000005	Rochdale MCD	40,437	39,823	-614	24.9%	24.5%	-1.5%
E08000006	Salford MCD	42,009	41,372	-637	23.5%	23.2%	-1.4%
E08000007	Stockport MCD	50,168	49,407	-761	22.0%	21.7%	-1.5%
E08000008	Tameside MCD	45,700	45,006	-693	26.5%	26.1%	-1.5%
E08000009	Trafford MCD	36,658	36,102	-556	21.4%	21.1%	-1.4%
E08000010	Wigan MCD	63,819	62,851	-968	25.8%	25.4%	-1.5%
E08000011	Knowsley MCD	30,646	30,181	-465	25.5%	25.1%	-1.4%
E08000012	Liverpool MCD	82,086	80,841	-1246	22.9%	22.6%	-1.5%
E08000013	St Helens MCD	35,983	35,437	-546	25.1%	24.7%	-1.7%
E08000014	Sefton MCD	53,994	53,175	-819	23.9%	23.5%	-1.7%
E08000015	Wirral MCD	57,985	57,105	-880	23.1%	22.8%	-1.4%
	North West total	**1,297,027**	**1,277,345**	**-19,683**	**23.3%**	**23.0%**	**-1.5%**

5. Discussion

The previous insight work carried out in the North West found that around half of people who were asked would find a duty on SSBs acceptable. This report has shown that a 20% duty on sugar sweetened beverages should reduce the total calorie intake across the population in the North West by an average of 10 kcal per person per day. This may seem small but has the potential to have an impact on obesity and incidence of obesity related diseases. Our results are based mainly on combining results from three models; the obesity modelled estimates produced by ERPHO/Natcen, the change in obesity from the Briggs, Mytton & colleagues' paper, and the change in obesity related outcomes from the paper by Wang and colleagues. It is estimated that over the next 20 years a 20% SSB duty would reduce the number of cases of diabetes by approximately 600 per year across the North West, cases of CHD and stroke by 400 per year, and cases of cancer by 100 per year. This would also lead to direct healthcare cost savings of approx. £3.9million and could generate revenue of around £30million which could be ring fenced to be spent on interventions that would benefit people's health in the North West, such as safe cycling schemes or subsidized healthy foods. As the proportion of income spent on SSBs is higher in the lowest income groups, any duty on SSBs would probably be regressive, having a greater effect on people on lower incomes, however this effect could be ameliorated if the revenue were spent on services targeted to the most deprived areas such as local food co-operatives. This 20% duty would also lead to approximately 10,000 Quality Adjusted Life Years (QALYs) gained per year across the North West population, which when at a willingness to pay threshold of £20,000 per QALY would be valued by society at around £200milllion. It is estimated that the SSB duty could also reduce obesity rates by 1.5% across the North West. There would also be benefits in terms of bone health, and improved oral health.

The model has used a high scenario based on manufacturer sales data, and a low scenario based on NDNS data. A more sophisticated model could use a set of probability density functions for each parameter and draw out 95% credible intervals. However this would require a lot more data on the likely distributions of the predictive parameters, which is lacking. When the NDNS produce their report on the relationship between self-reported and actual energy intake this may provide more evidence about how often SSB intake is under-reported. A US study with 250 people found that when their sample was reduced to include only those individuals whose reported calorie intake matched closely their measured intake using doubly labelled water ('true responders'), the association between SSB intake and obesity increased. In all responders the odds ratio of being overweight or obese was 2.6 for those who got more than 99 kcals per day from SSBs compared to those who did not drink SSBs, however when adjusted for inaccurate self-report the odds ratio increased to 4.5, indicating that the association between SSBs and obesity may be attenuated by inaccurate recall of SSB consumption.[33]

The model has not factored in some potential predictive parameters like wastage; the WRAP report estimated soft drink wastage at around 7%. We have not tried to estimate the potential additional effect a tax could have through a change in public perceptions; in France the 5% soft drinks tax has led to a drop in consumption of around 5%, which may be more through a change in psychology rather than the economic effect of a price rise on demand.[34]

There is a risk that a duty may have a smaller effect than anticipated because the SSB producers or vendors absorb some of the cost of the duty; this depends on the producer surplus, the amount of profit that is made on products. An excise duty on the volume of SSBs or the amount of sugar may have a

[33] Emond JA, Patterson RE, Jardack PM, Arab L. (2013) Using doubly labeled water to validate associations between sugar-sweetened beverage intake and body mass among White and African-American adults. Int J Obes (Lond). 2013 Jul 19. doi: 10.1038/ijo.2013.130.
[34] Credit Suisse Research Institute (2013). Sugar: Consumption at a Crossroads.

greater impact in this case, such as the 20p per litre duty recommended by Sustain. There is also the chance that consumers will continue to buy the same products, because they still think they are worth an increased price up to a given point; this excess that people are willing to pay is known as the consumer surplus. In the insight work several young people said that the price of the sugary drinks that they bought varied by so much that they were used to paying whatever price was charged. 1 There is also the chance that people may switch to bulk buying or cheaper products. A duty based on volume or amount of sugar would mitigate this effect. The insight work brought out the success of branding and status of SSBs; people want to drink Coca Cola, they don't want to be seen drinking 'Rola Cola'. But even though many people in the insight work said that a duty would not reduce their consumption, attitudes do not always predict behaviour, so even if a duty meant that young people consumed an SSB on their way to school on 4 days a week instead of 5 days a week, this would still have an impact.

More research is needed on the effects of price on SSB consumption, particularly in young people who are the greatest consumers. It may be a good idea for local interventions around SSB price and availability can be tried and evaluated. It would be interesting to look at the behavioural effect of price points, so for instance an increase of 95p to 99p for a drink would probably produce a smaller change in behaviour than from 99p to £1.02. In our work we have not considered ethnicity or deprivation directly, although these were used as inputs in the obesity modelled estimates we used. It may be useful to model the effects of an SSB duty on particular ethnic groups who have higher or lower SSB consumption, though at the moment there is not much evidence around differences in SSB consumption by ethnic group. For instance the NDNS does not include analysis by ethnic group. People of Asian origin have an increased risk of diabetes and CVD at a lower BMI than other ethnic groups (27.5 kg/m^2 instead of 30) so may be at higher risk of disease through SSB consumption.

Currently around 30% of soft drinks consumed in the UK are diet drinks. The insight work brought out people's worries and some of the myths surrounding artificial sweeteners. Even people who work in public health often think artificial sweeteners, in particular aspartame, are bad for health and can cause cancer despite them having been around for a long time and having been widely researched. In December 2013 the European Food Safety Authority published advice on aspartame which stated that it was regarded as safe for all populations, including children and pregnant women, the only exception being individuals with phenylketonuria.[35] It may be time to recognise that drinks with artificial sweeteners are likely to be the lesser of two evils, and recommend that public health practitioners should provide clear information about sweeteners.

The insight work and other evidence have suggested that the number of young people drinking energy drinks has increased a lot over the last ten years.[36] Energy drinks are the fastest growing category of soft drinks in terms of global sales. Reducing access to energy drinks should reduce calorie intake from these drinks and also reduce the risk of unwanted side effects such as young people being too hyperactive; [37] there have been anecdotal reports of young people having to be taken out of school because they have consumed too much energy drinks. The effects of daily exposure to high amounts of taurine for young people are not well researched. [38] Energy drink sales to young people are banned in Germany and in the UK one supermarket has recently banned energy drink sales to under 16s. [39]

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[35] See http://www.efsa.europa.eu/en/topics/topic/aspartame.htm
[36] See http://www.foodmanufacture.co.uk/Business-News/Energy-drinks-are-a-booming-business
[37] See http://www.eveshamjournal.co.uk/news/10731806.Energy_drinks_banned_after_youth_club_trouble/
[38] Seifert SM, Schaechter JL, Hershorin ER, Lipshultz SE. (2011) Health effects of energy drinks on children, adolescents, and young adults. Pediatrics 13(3):511–528.
[39] Smithers R. (2013) Morrisons bans children from buying high-energy drinks. The Guardian 22 November 2013 http://www.theguardian.com/society/2013/nov/22/morrisons-bans-high-energy-drinks-children

Some previous insight and survey work has suggested that people who drink SSBs as part of alcoholic drinks, such as gin and tonic often do not register that they are drinking calorific drinks. [40]Some people who normally drink diet drinks still drink sugary drinks with alcohol and there are beliefs that diet drinks do not taste as good with alcohol. The evidence from the NDNS and the Briggs paper showed that alcoholic beverages were a big source of calories so any intervention to reduce alcohol consumption like minimum alcohol unit pricing, or displaying the number of calories in alcohol drinks prominently, should have the potential to make a big difference to obesity rates as well as reducing alcohol related diseases and societal problems.

6. Thanks & Acknowledgments

This work was funded by the Food Active group and produced independently. Thank you to everyone who provided data and comments on this work.

7. Contact

To contact the Food Active campaign please email foodactive@hegroup.org.uk or telephone 0151 237 2686.

[40] See http://www.gla.ac.uk/news/archiveofnews/2012/april/headline_230642_en.html