Proposed Sugar Sweetened Drinks Tax: Health Impact Assessment (HIA)

Technical Report

IPH

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October 2012

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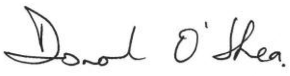
Foreword

Multiple measures are being considered and undertaken globally to confront the public health challenge of overweight and obesity. One proposal in the Irish context to address this is to introduce a 10% tax on sugar sweetened drinks. I was very pleased to be asked to chair the steering group of a Health Impact Assessment (HIA) for this proposal. Chairing the group demanded that I remove my hat as an advocate for measures to prevent and manage obesity and view the evidence and arguments presented from as impartial a position as possible. That is the essence of a HIA and indeed evidence-based practice. The process has been robust with an extensive literature review, a population profile, a stakeholder consultation, and a very active steering group which met regularly since April. In parallel a modelling exercise to gauge the potential impact on weight at a population level was carried out by Dr. Mike Rayner and his team in Oxford.

What became clear from the start of the process was that the polarised debate on this issue between the "we must do this" camp and the "it definitely won't work" camp would not inform the balanced review that a HIA demands. As the process evolved it was obvious that the reality - as with most situations - lies somewhere in the middle. While there is evidence linking sugar sweetened drinks to energy intake as you progress down the line to establish the link to weight gain the evidence becomes less robust and is suggestive but not conclusive. Certainly, there is no conclusive evidence that a specific tax on sugar sweetened drinks will impact on population weight - but absence of evidence does not mean a measure will not work. While some countries have introduced a tax on sugar sweetened drinks no country has carried out a HIA of this kind to predict its potential effects. If such a measure is introduced in Ireland there would be an opportunity to evaluate its impact prospectively. This would inform international practice by providing conclusive evidence of benefit or otherwise.

Action is needed and where evidence is lacking on measures it should be accumulated, with policies reviewed in that light. Only a sustained effort at a population and individual level involving a range of initiatives will have any chance of turning the tide of overweight and obesity.

I am grateful to the steering group for their time, enthusiasm and effort and to the Institute of Public Health in Ireland for their coordination of the overall process.



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Executive Summary

The Institute of Public Health in Ireland (IPH) was requested by the Department of Health to undertake a Health Impact Assessment (HIA) of a proposed tax on sugar sweetened drinks (SSDs). The public health priority for this proposal is to potentially address overweight and obesity in Ireland. HIA is a combination of procedures, methods and tools by which a policy, programme or project may be judged as to its potential effects on the health of a population and the distribution of those effects within the population. The information presented to the HIA steering group in making their conclusions and remarks to the SAGO group considered; a population profile, a stakeholder consultation and a literature review, while also taking into account parallel modelling work by a University of Oxford team and polling information that paralleled the HIA process.

In 2010, Ireland consumed 83 litres of carbonated beverages[1] per capita, and SSD consumption is currently higher among certain population subgroups than others. For example 37% of 18-64 year olds consume carbonated drinks compared to 9% of those aged 65 and older. Among young people in Ireland aged 5-18 years, 75% and over in each age cohort consume carbonated beverages. In general, males across all age categories are more likely to consume carbonated beverages, and consumption is more prevalent among lower socio-economic groups. Polling information demonstrated that respondents believe that children and young people drink too many SSDs.

Obesity is multifactorial; it is not caused by one facet of an individual's lifestyle, but instead can be caused by environmental, physiological, genetic and lifestyle factors. This complex mix of factors means that solutions to the problem of overweight and obesity are not simple but the food environment will certainly form an integral part of addressing this issue. Some of this complexity is reflected in the stakeholders' consultation where diverging views and uncertainty were apparent. Overweight and obesity in Ireland have reached concerning levels. In the National Adult Nutrition Survey (IUNA, 2012a), 37% of all adults were overweight and 24% were classified as obese. SLÁN (2007) (Harrington et al,

[1] See Appendix 5 for definition of carbonated beverage; in sum, 'carbonates' refer to sweetened non-alcoholic drinks containing carbon dioxide and therefore include artificially sweetened drinks. For a detailed breakdown of SSDs consumption by gender and age, please see table 3.8.

2008) results state that approximately 2 out of 3 Irish adults are either overweight or obese. Adult males are more likely to be overweight/obese than females across all age cohorts. Results from IUNA (2012c) stated that overall, 15% of children between 2 and 4 years old were overweight and 3% were classified as obese. Among children aged between 5 and 12 years, 17.4% were overweight and 6.7% were classified as obese while for teenagers (13-17 years) 15% were overweight and 3% were obese. The Growing up in Ireland study (2011) reported that 19% of children aged 3 were overweight, with a further 6% measuring as obese. A social gradient occurred for both adults and children with regard to weight – among adults this was not the case for overweight, but was the case for the prevalence of obesity.

The proposal for a tax on SSDs is rooted in concern over the problem of obesity in Irish society, and it is estimated that diseases associated with obesity will become increasingly common. Obesity can lead to serious health problems such as type 2 diabetes and metabolic disorder and although the causes of obesity are multifactorial, diet is one of the key influential factors. SSDs have come under considerable scrutiny for their possible contribution to overweight and obesity. SSDs are considered by some advocates as a good place to start in terms of food taxes as SSDs provide no nutritional benefits to the consumer. However others do not share the enthusiasm for a tax arguing that it is too simplistic a measure and not based on conclusive evidence.

What can be stated conclusively, as with any food/drink commodity, is that if energy intake exceeds energy expenditure there will be weight gain. Several mechanisms have been postulated to explain how consumption of SSD could lead to weight gain and obesity. The mechanism most often cited in the literature is one in which the 'liquid calories' of SSDs do not fully satiate appetite leading to additional consumption of calories in the diet. The evidence supporting this hypothesis is suggestive not conclusive. The question of satiety as unique to SSDs is mirrored by a possibly unique effect of SSDs on the body; for example, it is hypothesised but not proven that SSDs may contribute to diseases such as type 2 diabetes beyond the interaction with obesity through providing rapidly absorbable carbohydrates. The modelling exercise paralleling the HIA estimated that a 10% tax on the price of SSD, using an own-price elasticity of 0.9 for SSDs, would

reduce obesity by 1.25% among adults in Ireland. The reduction in SSD consumption would occur to a slightly greater extent among women than among men but there would be no discernable differences between income groups. If this were the outcome, this would be a major public health achievement but the predictions must be viewed with caution. The modelling exercise has limitations as with most exercises of this nature; these, including assumptions that were made, are outlined in the University of Oxford report. It made an assumption that 90% of the tax would be passed on. It did not take account of switching behaviour i.e. what will the consumer replace the SSD with. It cannot be certain that the predicted weight loss is accurate for smaller energy reductions below the validated range of the equations used in the model. However, equating reduced energy intake from such a measure with weight loss is extremely challenging – especially as this initiative would not be occurring in isolation.

The balance of evidence for a link between SSD consumption and higher energy intake is in favour of a positive relationship. The balance of evidence concerning a link between SSDs consumption and weight gain is less clear. Systematic reviews of published studies on SSDs consumption and weight gain vary greatly in their findings even though they often review the same published studies. However, overall the evidence linking SSDs consumption with weight gain is suggestive of a positive association rather than conclusive.

Meta-analysis of studies on SSDs consumption and increased energy intake show consistent positive relationships with small to medium effects. Small positive relationships also seem to emerge for meta-analyses on studies of SSD consumption and measures of weight gain. However, it also has to be considered that the meta-analyses have been conducted on a suite of studies that have variously been criticised in the literature for being at the lower end of the quality scale or having design flaws. There are few studies in any research area that do not have limitations, Mattes et al (2010) note that we are faced with imperfect knowledge. Most research taking place outside of a controlled laboratory environment has limitations. Compounding this imperfect knowledge is the fact that this is not occurring in a vacuum, there are other policy interventions and wider economic factors that may play a part; for example the potential

36% decrease in sugar prices that may be forthcoming in Europe as outlined in Bonnet et al (2011).

Steering Group Conclusion

The steering group believe the evidence presented to them by the HIA process demonstrated that:

- Obesity is multifaceted with many factors influencing the basic drivers of energy intake and energy expenditure including environment, socio-economic, psychosocial and genetic factors.
- SSDs are a source of energy intake with little or no other nutrient contribution to the diet.
- Price increases tend to decrease demand but the degree to which this happens is variable because consumer behaviour and industry response to a tax is difficult to predict.
- The evidence linking SSDs consumption with increases in energy intake is in favour of a positive relationship.
  The evidence linking SSDs consumption with weight gain is suggestive but not conclusive. The literature is contradictory and study quality tends to be described as low to medium.

There are a number of uncertainties surrounding these agreed points. Many of these uncertainties could be clarified by a comprehensive monitoring and evaluation process to ascertain consumption patterns, population BMI and industry impacts if the proposed tax was introduced. Causality and segmented data may be difficult to assess but the responsibility of planning for this monitoring and evaluation process lies with the Department of Health prior to introduction of the tax should it proceed. The HIA process was not asked to consider complementary measures and therefore cannot offer recommendations in this regard, however it should be noted that education and accompanying measures to promote physical activity were consistently raised by stakeholders as a necessary component of a suite of measures to address the issue. It should also be noted that the importance of engagement with industry prior to moving

forward with a tax has also been consistently raised by stakeholders, with the example of industry collaboration in the area of salt reduction cited as a precedent.

Institute of Public Health in Ireland

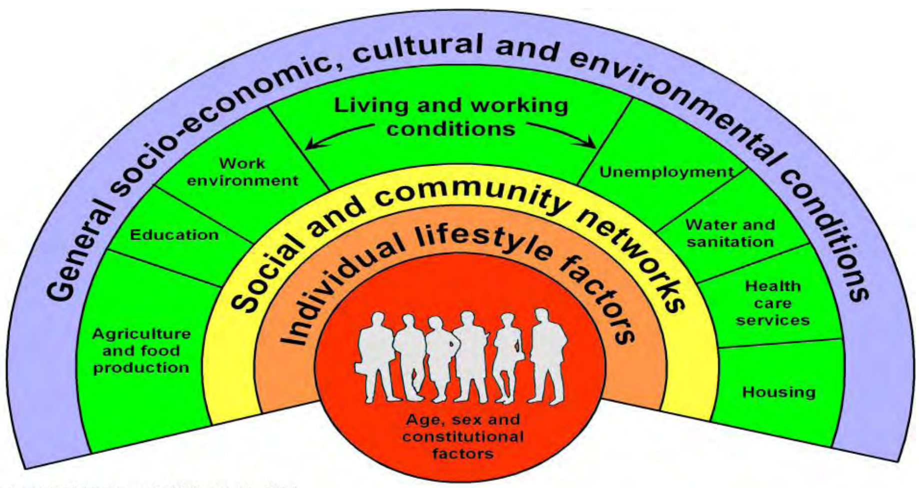
The remit of the Institute of Public Health in Ireland (IPH) is to promote cooperation for public health between Northern Ireland and the Republic of Ireland in the areas of research and information, capacity building and policy advice. Our approach is to support Departments of Health and their agencies in both jurisdictions, and maximise the benefits of all-island cooperation to achieve practical benefits for people in Northern Ireland and the Republic of Ireland.

1. Introduction to Health Impact Assessment (HIA)

HIA is a combination of procedures, methods and tools by which a policy, programme or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population.[2]

It is increasingly recognised that many factors outside of the health care sector influence health. The ability to reach and maintain good health is shaped not only by individual lifestyle factors and genetics, but also by the environment within which we live. This is portrayed in Figure 1.1, which illustrates the many layers of influence on people's health.

Figure 1.1: Determinants of Health[3]



Health Impact Assessment (HIA) can help to inform and influence the decision-making process by providing an evidence base on which to make decisions for health and well-being. It can also help to reduce health inequalities by highlighting not only where proposals may impact on the general population, but also within-group differences across the population.

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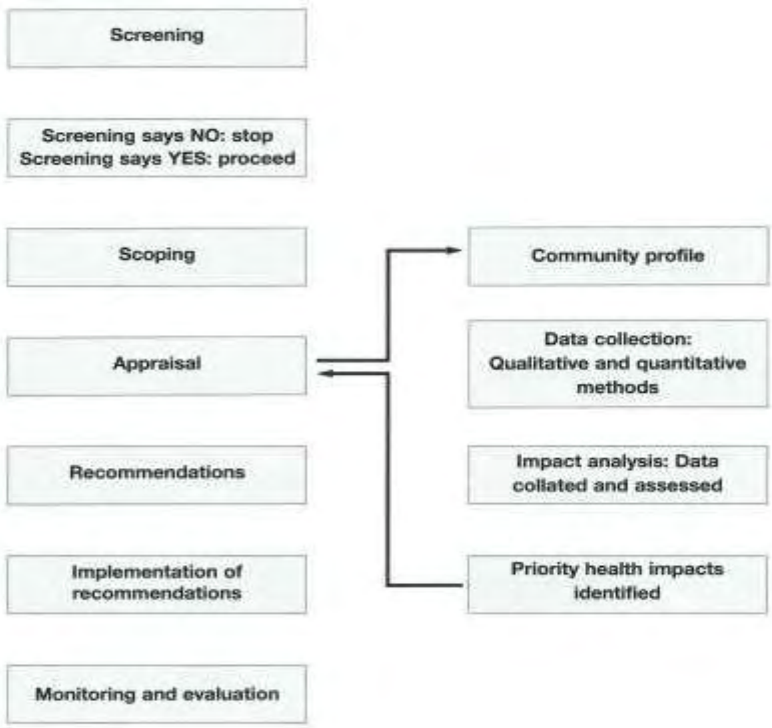
[2] WHO Regional Office for Europe. (1999). *Gothenburg consensus paper: health impact assessment; main concepts and suggested approach*. Brussels: European Centre for Health Policy.

[3] Dahlgren, G. Whitehead, M. (1991). *Policies and strategies to promote social equity in health*. Institute of Futures Studies, Stockholm.

The first step in a HIA is to screen the proposal to see if a HIA is warranted. If a HIA is warranted, a scoping process is undertaken to plan the HIA process. An appraisal phase follows which generally includes an overview of the population who would potentially be impacted, a review of relevant literature and consultation with stakeholders. The information gathered is typically analysed by the project team in conjunction with a steering group or advisory body. IPH has produced guidance[4] on the HIA process that includes the following main phases:

Figure 1.2: HIA Process



[4] http://www.publichealth.ie/publications/healthimpactsassessmentguidance2009 [Accessed 8 July 2012]

2. Overview of the HIA on the proposed Sugar Sweetened Drinks Tax

IPH received a request from the Department of Health to undertake a Health Impact Assessment (HIA) of a proposal for a sugar sweetened drinks tax. IPH presented an overview of what a HIA involves to the Special Action Group on Obesity (SAGO) in February 2012. A steering group was formed (see appendix 1), and IPH began developing the HIA. Screening and scoping (see appendices 2 and 3) were undertaken by the project team and presented to the steering group for approval. The project team developed a population profile to provide an overview of population health and also undertook a literature review. An important component of HIA is to consult with stakeholders and a stakeholder event was organised in June 2012. The project team identified key themes raised during this process and these served to inform the HIA.

In parallel to this process, the Department of Health requested Dr. Mike Rayner and his team in the University of Oxford to develop a modelling analysis which would also help decision making with regard to the proposal. In addition, the Department of Health asked Ipsos MRBI to poll adults in Ireland about their consumption and opinions of sugar sweetened drinks.

The public health priority for the proposed tax on sugar-sweetened drinks (SSDs) is to address overweight and obesity in Ireland. Therefore, the population profile and the literature principally focussed on the health impacts associated with overweight and obesity, including associated illnesses such as type 2 diabetes. As SSDs may also impact on dental health, the population profile and literature review also considered this potential impact.

As the determinants of health approach (see figure 1.1) is integral to a Health Impact Assessment, this HIA also considered the social gradient health impact of overweight, obesity and the impact of a tax across the population. These were core questions for the stakeholder event, as well as for consideration in the population profile, literature review as well as the work of Dr. Rayner and his team.

The evidence generated by the HIA process served to inform the conclusions for presentation to SAGO.

2.1 Policy Context

The World Health Organisation (WHO) has expressed growing concern over what it refers to as the global epidemic of overweight and obesity (WHO/FAO Joint Expert Consultation, 2003). In considering non-communicable diseases associated with overweight and obesity, this WHO/FAO joint expert consultation stated that changes in food consumption and availability as well as lifestyle and environmental factors have all contributed to this growing problem. The World Cancer Research Fund/American Institute for Cancer Research (2009) cites the increase in consumption of sugary drinks and processed energy-dense fast-food alongside the decline in physical activity, as leading to a global overweight/obese public health emergency. These bodies believe that this requires government intervention and sustained support at the highest levels, and that legal and fiscal measures should be designed to make healthier choices more affordable, accessible and acceptable (World Cancer Research Fund/American Institute for Cancer Research, 2009:92).

Goodman et al (2006), in their work for the WHO, considered economic instruments' effectiveness in reducing consumption of foods high in saturated fats and other energy-dense foods to prevent and treat obesity. They concluded that

Available evidence suggests – but does not demonstrate – that introduction of policy-related economic instruments, particularly in the form of taxes and price policies, could reduce food consumption, including of high saturated fat and other energy-dense foods, and increase the purchasing of healthful foods. (Goodman et al, 2006:21).

The Report of the National Taskforce on Obesity (2005) is the key policy document for Ireland in addressing the growing problem of overweight and obesity among the general population. This Report made 93 recommendations for the prevention and treatment of obesity, one of which was that research should be undertaken to examine the influence of fiscal policies on consumer purchasing and their impact on overweight and obesity. Certain items, including sugar sweetened drinks (SSDs), have a VAT rate of 23%. The

Taskforce report refers to some of the advantages and disadvantages to such taxation; such as making new revenue streams available for addressing obesity while recognising that such taxes are regressive.

A 2009 review of the Taskforce Report found that recommendations were partially implemented, and in response a Special Action Group was established by the Department of Health to work interdepartmentally and across agencies. The Minister for Health has proposed the introduction of a tax on SSDs and SAGO have undertaken a review to explore this proposed measure.

Introduction of such a tax would not be the first soft drink tax in Ireland; from 1916 until 1992 Ireland had a 'table waters' tax (Bahl et al, 2003). During the 1980s this special excise was levied at IR£0.37 per gallon, but reduced to IR£0.29 per gallon in 1990 until abolition in 1992 when it was replaced with the top-tier VAT rate. Bahl et al (2003) estimate the 10% price reduction led to an 11% increase in the number of litres consumed.

The principal reason for the 'table waters' tax was to generate revenue, however the principal reason for proposing to introduce a SSDs tax by the Department of Health is to sway consumer behaviour. This would not be the first fiscal policy which intends to change consumer behaviour in the interests of population health. Ireland places tax on tobacco and alcohol which is in line with many other States. Other countries such as Hungary, France and Denmark all have 'fat taxes' – taxation to deter consumption of fats in the diet and France also has additional duties on soft drinks, while individual U.S. states have beverage taxes on sugar sweetened drinks (see Mytton et al, 2012).[5] Since the introduction of the French beverage tax in January 2012, soft drink sales declined by 3.3% although possibly to the advantage of supermarket brands.[6] Many countries outside the EU also impose SSD taxes. The rationale for these taxes vary between health and economic considerations, but overall SSD taxes are considered a good source of revenue

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[5] Hungary intends to undertake a HIA and evaluation process in 2012. Denmark is considering withdrawing its taxes in its forthcoming budget. The FDII note that Ireland's existing 23% VAT applied to SSDs is higher than 'sin' taxes that apply to SSDs in other European jurisdictions.
[6] 'Le marché des soft-drinks a la gueule de bois' by Keren Lentschner in *Le Figaro* (26 July 2012) [http://lequotidien.lefigaro.fr/epaper/viewer.aspx Accessed 31 July 2012].

to the State in a similar vein to tobacco and alcohol – these are not necessities and therefore the population has a choice to pay these taxes.

3. Population Profile

3.1 Introduction

This population profile adheres to best practice in HIA methodology. Data is drawn from high quality secondary sources and presented on three main themes: demography and health; trends in the consumption of SSDs and current and emerging trends in the beverage market in Ireland.[7] It aims to provide a baseline of demographic data relevant to gauge a better understanding of how the HIA on the proposed introduction of a tax on SSDs may impact the lives of the population. Data is presented at national level and where relevant, and available, data is broken down and discussed by gender, age and socioeconomic status, allowing for distinction between groups within the population who are likely to be more or less affected by the proposed policy.

3.2 Demography and Health

The Republic of Ireland (ROI) has a population of 4,588,252. Overall women outnumber men at a rate of 100:98.1 but this is reversed in the population aged 19 or younger where the rate is 100:104.6. Two thirds of the population (67%) are aged 15-64, over one fifth (21.3%) are aged 14 or younger while 11.7% are aged 65 or older (CSO, 2012a). There was a noticeable upward shift in the social class status of the population between the 2006 and the 2011 census. Substantially more people reported a higher social class in 2011 compared to 2006 (CSO, 2012b). Those in full-time education increased in this period by 16.9% (CSO, 2012c). The most significant increase was observed in higher age groups, reflecting a long-term trend in rates of participation in education and the effects of the economic downturn. The percentage of the population both at risk of poverty and in consistent poverty is rising (CSO, 2012d). Income inequality is also increasing: in 2010 the average income of those in the highest income quintile was 5.5 times that of those in the lowest income quintile, compared to 4.3 in 2009 (CSO, 2012d).

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[7] An additional appendix report containing more detailed socio-demographic and healthcare utilisation data has been compiled as supporting documentation and is available upon request.

Life expectancy varies according to a range of socioeconomic factors; life expectancy at birth is greatest in more affluent areas, with higher levels of educational attainment and working in more professional jobs (CSO, 2010). Average life expectancy at birth in Ireland is 78.7 years for men and 83.2 years for women. The gender gap in life expectancy persists across the life span but narrows with increasing age from 4.8 years at birth to 3.2 years aged 65, reflecting the higher number of deaths among young and middle aged men (Eurostat, 2012).

3.3 Health Status

The majority of the population report favourable self-rated health status. However some trends in unfavourable health status are evident. There is a clear trend towards better self-rated health for every increase in social class (CSO, 2012c) and education level attained in the general population (CSO, 2012d). Health status also varies by age group and there is a noteworthy increase in the proportion of people in older age groups reporting poorer health status in recent years (CSO, 2012c). Furthermore, in the recent census a concentration of less favourable health was observed for Ireland's major cities compared to other regions (Dublin, Cork, Limerick and Waterford) (CSO, 2012c) reflecting poorer self-reported health for people living in urban centres.

3.4 Overweight and Obesity

Overweight and obesity are becoming increasingly prevalent in Ireland and vary considerably according to age, gender and social class. Body mass index (BMI) is used to estimate the prevalence and associated risks of overweight and obesity within a population. The tables below show data from two recent population studies in Ireland. The National Adult Nutrition Survey (IUNA, 2012a), conducted from October 2008 to April 2010, used measured height and weight to calculate BMI. WHO BMI cut-off points were used to estimate levels of overweight (25.0-29.9 kg/m2) and obesity (≥30.0 kg/m2). The Survey of Lifestyles, Attitudes and Nutrition (SLÁN) (Morgan et al, 2008), conducted in 2007, used self-reported height and weight, while a subsample of the same respondents aged 18-44 and 44+ had their height and weight measured (anthropometric data).

Based on anthropometric measures in the National Adult Nutrition Survey[8] (IUNA, 2012a) the prevalence of obesity in 18-64 year old adults has increased substantially since 1990, from 8% to 26% in men and from 13% to 21% in women. The greatest increase has been observed in men aged 51-64 years. Overall, 37.1% of all adults between 16 and 64 years were overweight and 23.4% were classified as obese. There is a clear trend in increasing levels of obesity as adults get older. Among 18-35 year olds, 13.1% were obese compared to 27.3% of 36-50 year olds and 36.4% of 51-65 year olds. The trend reversed in older ages with just under a quarter 24.5% of those over 65 years having a BMI measurement indicating obesity. A similar age trend is observed in the proportion of adults overweight in the sample: 41.5% of 51-64 year olds are overweight compared to 32.5% aged 18-35 years. However, over half of those aged 65 years and over are overweight. A higher proportion of males are both overweight (44%) and obese (26%) compared to females (31 % overweight and 21% obese) in all ages.

Table 3.1: Overweight and obesity among adults by age and gender (IUNA, 2012a)

BMI category	Age group	Characteristic		
		Males %	Females %	All %
Overweight	18-64	43.8	30.7	37.1
	18-35	39.6	25.0	32.5
	36-50	49.7	31.3	39.8
	51-64	43.6	39.6	41.5
	>= 65	58.8	48.5	53.2
Obese	18-64	25.7	21.2	23.4
	18-35	13.0	13.3	13.1
	36-50	31.3	23.8	27.3
	51-64	42.1	30.9	36.4
	>= 65	24.7	24.3	24.5

Direct comparison of measured and self-reported data in the SLÁN studies clearly shows that self-reported data underestimate the true prevalence of overweight and obesity when compared to the measured data, providing an underestimation of the true prevalence of overweight and obesity in Ireland (Shiely et al, 2010). Nonetheless, in self-reported BMI data from SLÁN 2007 (table 3.2), approximately 2 out of 3 Irish adults were at an unhealthy weight (either overweight or obese) and almost one out of 4 adults was obese (Harrington et al, 2008). SLÁN data supports the trend in higher rates of overweight

[8] Body Mass Index was calculated from anthropometric measurements of weight and height data.

and obesity among males and older adults up to age 65 years, after which a modest decrease occurs (Morgan et al, 2008). Overall, 43% of males and 28% of females self-reported a BMI indicating being overweight. Respectively, 16% of males and 13% of females reported a BMI indicating obesity.

A social class gradient was evident for obesity, although not for overweight levels: respondents from lower social classes (SC 5 and 6) were more likely to report a BMI indicating obesity than those from higher social classes (SC 1 and 2). Overall obesity rates were higher in males compared to females. There was no evidence of a social class gradient for obesity in males; in fact those from more affluent backgrounds (SC 1 and 2) are more likely to report a BMI indicating obesity compared to those from a lower social class background (SC 5 and 6). However a clear social class gradient was evident among females: almost 4% more females in social class 5 and 6 reported a BMI indicating obesity compared to those in social class 3 and 4 and 7.2% more than those in the highest social class grouping, social class 1 and 2.

There is no single source of BMI data on children under 18 years. Data are currently available from five studies citing two different surveys on: children aged 3 and aged 9 (Growing up in Ireland) and aged 2-4, 5-12 and 13-17 (IUNA Pre-School, Children's and Teens Food Surveys). Tables 3.3 and 3.4 show the proportion of children aged between 2 and 17 years classified as overweight and obese based on the International Obesity Task Force (IOTF) age and gender specific cut-offs applied to the IUNA survey data.

Table 3.2: Overweight and obesity among adults by age, gender and social class (Findings from measured data in brackets) (Morgan et al, 2008; Harrington et al, 2008; Department of Health (DOH), 2011)

BMI category	Gender	Age groups	Characteristic Social Class (SC) %			
			1-2	3-4	5-6	All Social Class
Overweight	Male	18-29	33	26	28	
		30-44	51	44	40	
		45-64	56	54	42	
		65+	48	45	42	
		All ages				43 (44)
	Female	18-29	20	20	11	
		30-44	26	28	40	
		45-64	33	33	40	
		65+	32	37	34	
		All ages				28 (31)
	Both	All ages	39	36	36	36 (38)
Obese	Male	18-29	6	6	8	
		30-44	15	18	24	
		45-64	20	20	25	
		65+	16	16	17	
		All ages				16 (22)
	Female	18-29	6	8	8	
		30-44	11	13	24	
		45-64	16	20	18	
		65+	12	12	12	
		All ages				13 (23)
	Both	All ages	6	15	19	14 (23)
Overweight and obese (BMI >=25)	Male	All ages	63.4	57.4	57.8	
	Female	All ages	38.9	42.3	46.1	
	Both	All ages	51.7	50	53.4	

Overall, 15% of children between 2 and 4 years were overweight and 3% were classified as obese. A slightly higher percentage of girls were classified as overweight or obese (19%) compared to boys (16%). Children aged between 2 and 3 years were more likely to be either overweight or obese compared to those aged 4 years, reflecting rapid fluctuations in BMI that occur during normal growth and development at these ages. However, there is a noticeable trend in increasing levels of body mass for younger children. Among children aged between 5 and 12 years, 17.4% were overweight and 6.7% were classified as obese. 15.0% of teenagers (aged 13 to 17 years) were overweight and 3% were obese. More male teenagers were classified as both overweight and obese.

Table 3.3: Overweight and obesity among pre-school children by age and gender (IUNA, 2012b)

BMI category	Characteristics			
	Gender	Age (% in years)		
		2	3	4
Overweight	Male	13%	21%	6%
	Female	13%	23%	13%
	Both	13%	22%	10%
Obese	Male	5%	5%	0%
	Female	4%	3%	0%
	Both	4%	4%	0%

Table 3.4: Overweight and obesity among children by age, gender (IUNA, 2005; IUNA, 2008)

BMI category	Characteristics				
	Gender	Age group (in years)[9]			
		5-8	9-12	13-14	15-17
Overweight	Both	18.2	16.7	16.6	13.8
	Males	/	/	16.0	14.7
	Females	/	/	14.2	12.9
Obese	Both	6.7	6.7	4.3	2.0
	Males	/	/	5.3	0.8
	Females	/	/	3.2	3.2

Growing up in Ireland (GUI, 2011) reported that 19% of children aged 3 were overweight, with a further 6% measuring as obese according to the IOTF classification of BMI. Children's weight was related to household social class: 9% of 3 year old children from the most socially disadvantaged group were obese compared to 5% of children from the most socially advantaged households. This social gradient was also evident among 9 year olds in the GUI sample with a higher proportion of children from semi-skilled or unskilled backgrounds classified as overweight (20%) and obese (11%) compared to children from professional/managerial backgrounds. Overall, 19% of 9 year olds were found to be overweight and 7% were obese.

[9] Data on gender breakdown for age groups 5-8 and 9-12 are not available.

Table 3.5: Over-weight and obesity among children by age and social class (GUI, 2011; Layte et al, 2011)

BMI category	Characteristics		
	Social Class (SC)[10]	Age	
		3 yrs	9 yrs
Overweight	1-2	18%	18%
	3-4	20%	20%
	5-6	22%	20%
	All SC	19%	19%
Obese	1-2	5%	4%
	3-4	6%	8%
	5-6	9%	11%
	All SC	6%	7%

Girls were more likely than boys to be classified as overweight (22% compared to 16%) and obese (8% compared to 6%) and a social gradient was most evident for 9 year old girls.

3.5 Chronic Conditions

Chronic conditions are the leading cause of mortality in Ireland and also contribute substantially to disability burden in later years. Specifically, cancer and diseases of the circulatory system together, accounted for almost two thirds of all deaths in 2010 (DOH, 2011). To date, several risk factors have been established for a range of chronic conditions. The prevalence of chronic conditions increases with age and they are slightly more prevalent among women compared to men (CSO, 2012d). With the exception of hypertension, high cholesterol and anxiety/depression, the prevalence rate of chronic conditions is relatively low for people under 45 years. However for each of these conditions 4% of the Irish population aged between 35 to 44 years reported a diagnosis (CSO, 2011). A substantial proportion of people with medical cards have a chronic condition; this may reflect age-related patterns in medical coverage it is also likely to be reflecting a social gradient in health also observed for limitations in daily activities due to health problems (CSO, 2012d).

[10] Growing Up in Ireland studies categorise Social Class as Professional/Managerial, Other Non-Manual/Skilled Manual and Semi-Skilled/Unskilled. For comparability these have been categorised as 1-2, 3-4 and 5-6 respectively.

Several modifiable factors including obesity increase the risk of chronic conditions. The risk of coronary heart disease (CHD), stroke, type 2 diabetes, certain cancers and musculoskeletal conditions all increase steadily in line with increases in body mass (Mathers, 2009). There is currently a high proportion of people in Ireland living with these debilitating chronic conditions, furthermore the prevalence of these conditions are forecast to increase in the coming decade (Balanda et al, 2010). Overall the prevalence of cancers in ROI is 2% (CSO, 2011). While data is not available on prevalence forecasts for cancer, IPH has produced several reports detailing current and forecasted prevalence rates for CHD, stroke, diabetes, hypertension and musculoskeletal conditions. Increased BMI level was identified as a significant predictor for hypertension, diabetes, and musculoskeletal conditions by IPH in modelling the predicted prevalence of chronic conditions from SLÁN 2007 data.[11] Detailed tables on estimates each condition for 2010, 2015 and 2020 are provided in Appendix 4.

Mortality rates for CHD in Ireland are among the highest in Europe. IPH estimate that more than 2.4% of Irish adults aged 18 years and over have clinically diagnosed CHD[12] (IPH 2012a). Overall, mortality rates from CHD have halved in the last 20 years. A study on CHD rates in Ireland (Kabir et al, 2007) attribute 40% of the gain in life years from the reduction in CHD deaths in the past two decades to advances in medical therapies. The majority of gains were attributable to a reduction in risk factors of which 65% were attributed to a reduction in cholesterol levels. Although, increasing adverse trends in established risk factors for CHD including obesity, diabetes and physical activity coupled with population ageing are likely to lead to a reverse in this trend and an increased burden of CHD in years to come. By 2020 the population prevalence of CHD is expected to rise to 2.9% (IPH, 2012a). This represents a 31% increase in the numbers of people living with CHD in 10 years.

It is expected that overall population prevalence of stroke will increase by 0.1% by 2020 representing a forecast increase of 6,053 adults with stroke in the population (IPH 2012b).

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[11] Full details of IPH modelling methodology for each chronic condition: http://chronicconditions.thehealthwell.info

[12] Figures are based on self-reported, doctor-diagnosed angina or heart attack in the previous 12 months from SLÁN 2007. Future forecasts are based on the CSO's population projections (M0F1 Recent variant).

Stroke is more common as age increases; 2.8% (6,135) of people aged 75 years and over reported a clinical diagnosis of stroke compared to 0.3% (1,815) of people aged between 45 and 55 years in 2010. Prevalence rates for stroke are similar for men and women. The rate of diabetes[13] for adults aged 18 years and over is also expected to rise to 3.8% (136,000 people) by 2020 (IPH 2012c). This represents a 28% increase (an additional 30,000 adults aged 18 years and over) in ten years. Prevalence is estimated to be higher in women compared to men and diabetes risk increases substantially with age. Prevalence in people aged 55 years and over is double that of people aged 45 to 55 years (IPH, 2012c). Prevalence is expected to rise largely due to an increased incidence of type 2 diabetes resulting from the reported increase in childhood and adolescent obesity levels. IPH estimates that almost two-thirds (62.2%) of Irish adults have hypertension, with an expected 28% increase occurring by 2020 (IPH, 2012d). Population estimates of musculoskeletal conditions include: back conditions; osteoarthritis and rheumatoid arthritis from 2010 to 2020 (IPH forthcoming). It is estimated that back conditions will have the highest prevalence rate (12.6%) of all three musculoskeletal conditions by 2020. By the same year, it is expected that 6.1% of the Irish population will have rheumatoid arthritis and 5% will have osteoarthritis.

It is noteworthy that by definition, undiagnosed cases are not usually included in prevalence data for chronic conditions and estimates are likely then to be an underestimation of the true prevalence of these chronic conditions. Therefore current data forecasts are also likely to be conservative.

3.6 Dental Health

There is a clear decline in dental health across age groups according to increased frequency of sweet food/drink consumption (table 3.6). The mean number of natural teeth retained reduces according to the number of times sweet foods or drinks are

[13] Figures include type 1 and type 2 diabetes combined and based on findings from SLÁN 2007. Data for 18-44 year age groups are clinically diagnosed diabetes based on self-reported, doctor-diagnosed diabetes in the previous 12 months or reported taking diabetes medications in SLÁN 2007. No data were available on undiagnosed diabetes for 18-44 years. Data for 45+ year age groups are clinically diagnosed diabetes based on self-reported, doctor-diagnosed diabetes in the previous 12 months or reported taking diabetes medication and undiagnosed diabetes (no clinical diagnosis in the previous 12 months and not taking diabetes medication but physically measured as diabetic (HbA1c>=6.5%).

consumed. This trend is most evident in those over 65 years: those consuming sweet food/drink less than three times a day have on average 6 more natural teeth than those consuming sweet food/drink more than five times a day. This trend is also evident in younger age groups with those 16 to 24 year olds consuming sweet foods/drinks more than five times a day having on average one more decayed, missing or filled tooth than those consuming sweet foods/drinks, less than three times per day. Poorer dental health was also observed among a sample of children aged 8 years and 15 years consuming sweet snacks more frequently than their counterparts (table 3.7). Fifteen year olds, who consumed a sweet snack more than four times per day, had on average one more missing tooth than those who consumed one or no sweet snacks per day. This trend is evident, although more modest among 8 year olds.

Table 3.6: Dental health among adults by frequency of sweet food/drink and age (Department of Health and Children (DOHC), 2007)

Dental health	Frequency of sweet foods/drink	Characteristic Age		
		16-24	35-44	65+
Mean number of natural teeth present	Less than 3 times/day	28.2	25.8	14.9
	3-4 times/day	28.3	24.7	13.3
	Five or more times/day	27.9	23.6	9.0
Mean number of decayed, missing, filled teeth	Less than 3 times/day	4.8	14.7	21.3
	3-4 times/day	5.1	15.6	23.8
	Five or more times/day	5.7	15.5	25.9

Table 3.7: Dental health among children by frequency of sweet snacks between meals by age group (DOHC, 2006)

Dental health	Frequency of sweet snacks between meals	Characteristic	
		Age (in years)	
		8	15
Mean number of decayed, missing, filled teeth	Never/once a day	0.4	2.5
	2-3 times a day	0.4	2.8
	4 or more times a day	0.5	3.4

The social gradient found in general health is also observed in dental health among adults and children. The retention of natural teeth in adulthood is substantially lower among those from more disadvantaged backgrounds.[14] Children aged 15 years have on average

[14] Measured by medical card status.

3.1 decayed, missing or filled teeth; the figure is higher in children with medical cards (3.4) compared to those without (3.0). Children as young as 5 years with a medical card, show an increased rate of poor dental health compared to their counterparts regardless of fluoridation status of their water supply.

3.7 Trends in the consumption of sugar sweetened and other beverages in the Republic of Ireland

Data on the consumption of SSDs are taken from several sources. Information on beverage consumption patterns by age and gender is provided by a series of four national nutritional surveys conducted by the Irish Universities Nutrition Alliance (IUNA). These are: The National Children's Food Survey (2005) of children aged 5-12 years; The National Teen's Food Survey (2008) of teenagers aged 13-17 years; The National Adult Nutrition Survey (2011) of adults aged 18-90 years and most recently The National Pre-School Nutrition Survey (NPNS) of children aged 1-4 years (2011). A comprehensive overview of the soft drinks market in the Republic of Ireland by Canadean[15] provides further information on the consumption patterns of a range of beverages in Ireland. Discussion focuses on SSDs, however data on other beverages is presented for comparison purposes. Information on leading companies, market value and distribution of the beverage industry in Ireland is presented in the succeeding section of this report.

During the course of the National Adult Nutrition Survey (IUNA, 2012a) participants recorded 2,552 individual food items in a four day food diary. These items were then allocated to one of 68 food groups, five of which represented different beverages as follows: carbonated beverages (non-diet); diet carbonated beverages; squashes, cordials, fruit juice drinks; fruit juice; and, other beverages (including water). Similar data on beverage consumption were recorded in the surveys for teens, children and pre-school children. As the same methodology was applied to these two surveys as the National Adult Survey, it is possible to compare findings across all age cohorts; from 12 months to 90 years of age. There was a slight change in the terminology used in the pre-school children survey: carbonated (non-diet) beverages were referred to as 'soft drinks, not low calorie' and diet carbonated beverages were referred to as: 'soft drinks, low calorie'.

[15] *Republic of Ireland soft drinks review, 2011 Cycle*

Data is presented in tables 3.8 and 3.9 on the percentages in each age cohort consuming different beverage types and the mean beverage consumption levels. The mean level of consumption is presented for consumers only (i.e. those who indicate that they consume the beverage). While mean consumption levels are a good indicator of beverage intake in the groups, it is also important to note that some individuals may be driving the average intake level up through excessively high levels of consumption. Therefore the 5th and 95th percentile for consumption levels are also presented in the tables indicating differences (or variance) in consumption patterns within gender and age groups. For example, the average consumption of carbonated (non-diet) drinks for men aged 18-35 years is 256 grams per day (g/d), however, consumption levels for the highest 5% of consumers (95th percentile) in this group exceeds 651 g/d. Alternatively, the lowest 5th percentile of men in this group consume less than 52 g/d.

The IUNA survey of adults (2012a) found higher consumption of all carbonated (diet and non-diet) drinks among younger adults. There is a gradual decline in the consumption of sugar sweetened carbonated drinks (i.e. non-diet) as age increases, indicating a cohort effect. For example 61% of men aged 18-35 drink non-diet carbonated drinks compared to 21% aged 51-64 and 10% of those aged over 65 years. Consumption patterns also vary according to gender, especially for carbonated drinks. Young women are far more likely to drink diet carbonated drinks (27%) than their male counterparts (11%), whilst a higher proportion of younger men drink non-diet carbonated drinks (61%) compared to young women (44%). Squashes, cordials and fruit juice drinks are consumed to a lesser extent, although consumption of these is highest among younger adults. Few older adults drink carbonated drinks (<10%) or squashes (<6%). Approximately one third of all adults consume fruit juices with little variation between age groups, although it is most commonly consumed by older females (48%) and younger adults (45%). On average people over 65 years drink less water than younger adults and a lot fewer older men drink water (55%) compared to older women (79%).

Older adults recorded the lowest average level of carbonated (non-diet) beverage consumption for all adults. Mean consumption levels in general decreased with increasing age. For example, women 65+ consumed on average 71 g/d compared to 230

g/d for women aged 18-35 years. Young adults and males in particular recorded the highest average consumption of carbonated drinks (256 g/d) compared to any other group. However young women recorded higher consumption levels in the 95th percentile (668 g/d) compared to young men (651 g/d) indicating that some young women drink substantially high levels of carbonated drinks. Women consumed on average a higher amount of diet carbonated drinks than their male counterparts in the younger age group (18-35), however for every other age group, men consumed more on average than women. Levels of consumption within groups varied substantially with consumption in younger women varying between 50 g/d in the lowest 5th percentile and 536 g/d in the highest 95th percentile. Older men showed a surprisingly high variance in consumption levels of diet carbonated drinks; ranging from 83g/d in the lowest 5th percentile to 1000 g/d in the highest 95th percentile. Their mean consumption (419 g/d) was almost double that of women in the same age group (218 g/d). Adults aged 36-64 years recorded the lowest average level of diet beverage consumption overall.

Highest mean levels of consumption for any adult age group were recorded for water. Men consumed 34.7 grams more water per day on average compared to women. Young men were the highest consumers of water, drinking on average 943g/d compared to older men who consumed the least, on average 427g/d. In general, levels of water consumption also decreased with age. There was a low average consumption of fruit juices among adults compared to all other beverages except squashes, cordials and fruit juice drinks. Younger men drank on average more fruit juice than any other group. Women recorded a lower rate of fruit juice consumption compared to men in general. Low levels of intake were recorded for both men and women across age groups for squashes, cordials and fruit juice drinks. However, on average younger men (83 g/d) and women (81 g/d) were the highest consumers of these products.

Table 3.8: Beverage consumption patterns among children, teens and adults according to age and gender (IUNA, 2012a; IUNA, 2008; IUNA, 2005)

		Characteristic							
Beverage	Gender	Age group (% in years)							
		5-8	9-12	13-14	15-17	18-35	36-50	51-64	65+
Carbonated (non-diet)	Male	81%	84%	86%	81%	61%	37%	21%	10%
	Female	76%	77%	88%	75%	44%	24%	20%	8%
Diet carbonated	Male	20%	20%	15%	16%	11%	9%	5%	3%
	Female	73%	71%	18%	21%	27%	14%	9%	2%
Squashes, cordials, fruit juice drinks	Male	83%	76%	49%	43%	24%	13%	11%	5%
	Female	81%	73%	54%	36%	23%	9%	8%	6%
Fruit juice	Male	69%	64%	59%	57%	45%	34%	33%	38%
	Female	75%	74%	69%	64%	45%	38%	33%	48%
Other, including water	Male	90%	88%	87%	90%	86%	70%	70%	55%
	Female	93%	92%	92%	97%	89%	88%	85%	79%

Data on consumption patterns in children and teens is presented in table 3.8. As with adults highest consumption was recorded for water, although high levels of consumption were also recorded for carbonated drinks. Percentages of those consuming sugar sweetened carbonated drinks ranged between 75% in girls aged 15-17 to 88% in girls aged 13-14 years. Over 81% of boys aged between 8-17 years drink carbonated (non-diet) drinks. Girls are more likely to drink diet carbonated drinks: 71% of those aged 5-12 years consume diet drinks compared to 20% of boys the same age. High percentages of children aged 5-12 years consume squashes, cordials and juice drinks (>73%) and high percentages of children in this age group also consume fruit juice (>64%). Only small proportions of teens consume diet carbonated drinks (<21%) compared to carbonated (non-diet) (>75%) or any other beverage (>36%).

Teenage boys had the highest recorded level of average carbonated (non-diet) drink consumption (272 g/d) reaching 723 g/d in the highest (95th) percentile. They also recorded the highest average consumption of diet carbonated drinks (123-141 g/d).

Table 3.9: Consumption of beverage type in grams per day (g/d) for children, teens and adults by age, gender and levels of consumption: mean consumption, low consumption (5th percentile) and high consumption (95th percentile) (IUNA, 2012a; 2008; 2005)

Beverage	Characteristic									
	Gender	Measure	Age group (in years)							
			5-8	9-12	13-14	15-17	18-35	36-50	51-64	65+
Carbonated	Male	Mean	124	207	218	272	256	224	204	103
		Low (5th)	18	29	36	47	52	50	61	34
		High (95th)	343	577	550	723	651	649	578	253
	Female	Mean	114	165	200	201	230	171	115	71
		Low (5th)	24	29	31	31	38	36	22	24
		High (95th)	276	420	583	629	668	624	413	138
Diet carbonated	Male	Mean	54	98	123	141	180	148	215	12
		Low (5th)	7	16	23	24	63	28	83	0
		High (95th)	186	405	332	464	394	375	505	0
	Female	Mean	73	71	114	108	206	122	163	218
		Low (5th)	10	14	14	27	50	27	31	136
		High (95th)	190	215	357	453	536	363	500	300
Squashes, cordials, fruit juice drinks	Male	Mean	94	90	97	85	83	64	76	56
		Low (5th)	9	6	7	6	13	8	5	10
		High (95th)	228	269	424	297	215	254	300	156
	Female	Mean	89	96	57	64	81	50	56	44
		Low (5th)	6	8	5	6	7	4	8	10
		High (95th)	243	245	164	208	278	247	124	125
Fruit juice	Male	Mean	117	136	140	160	157	139	135	114
		Low (5th)	20	21	7	29	34	24	32	24
		High (95th)	279	424	359	501	399	433	355	250
	Female	Mean	139	137	124	134	118	104	97	104
		Low (5th)	19	14	20	29	16	3	9	3
		High (95th)	375	388	350	343	305	245	264	254
Other, including water	Male	Mean	246	306	409	529	943	623	492	427
		Low (5th)	24	22	63	43	125	63	52	39
		High (95th)	614	797	1188	1382	2405	1734	1792	1259
	Female	Mean	213	288	383	467	718	584	542	502
		Low (5th)	22	30	48	65	63	50	50	36
		High (95th)	556	693	832	1331	1995	1610	1572	1594

Young girls (aged 5-8) had a higher level of consumption of diet carbonated drinks than young boys of the same age. However this trend reversed for girls and boys aged 9-12. Average water consumption increased with increasing age and boys consumed higher average daily amounts compared to girls in any age group. A high average rate of daily consumption was recorded for fruit juices among all ages of children and teens compared to adults and mean consumption rates were highest among boys in general, except for

the youngest age group (5-8 years) where girls consumed 22 g/d on average more than boys. Teenage girls on average consumed less squashes, cordial and fruit drinks compared to teenage boys.

Table 3.10: Mean beverage intake in grams per day among all and among consumers only in pre-school children (IUNA, 2012c)

Beverage	Characteristic				
	Measure	Age (in years)			
		1	2	3	4
Soft drinks, not low calorie	Mean (all)	21	49	52	77
	Mean (consumers)	96	117	111	145
	% consumers	21%	42%	47%	53%
Soft drinks, low calorie	Mean (all)	68	103	104	111
	Mean (consumers)	233	228	198	223
	% consumers	29%	45%	52%	50%
Fruit juices	Mean (all)	23	38	65	77
	Mean (consumers)	69	81	105	118
	% consumers	33%	47%	62%	65%
Water	Mean (all)	126	164	135	131
	Mean (consumers)	167	219	172	181
	% consumers	75%	75%	79%	73%

Table 3.10 presents data on the beverage consumption patterns of pre-school children. The mean level of consumption is presented for all children, including consumers and non-consumers.

Consumption of soft drinks increased with increasing age. The percentage of children consuming low calorie soft drinks increased from 29% in 1 year olds to 50-52% in 3 and 4 year olds with average daily intake among consumers of 198-233g. For sugar-containing soft drinks, the percentage of consumers increased from 21% in 1 year olds to 53% in 4 year olds with average daily intake among consumers increasing from 96g to 145g respectively. Water was consumed as a beverage by 73-79% of pre-school children with the average daily intake increasing with increasing age from 145g in 1 year olds to 181g in 4 year olds. The percentage of children consuming fruit juice increased from 33% in 1 year olds to 65% in 4 year olds with average daily intake among consumers increasing from 69g in 1 year olds to 118g in 4 year olds.

The Irish Health Behaviour in School-aged Children (HBSC) 2010 study (Kelly et al, 2012) also provides information on soft drink consumption in children and teenagers. Overall,

21% of children report drinking soft drinks daily or more often. There are statistically significant differences by gender, age group and social class. Overall, 23% of boys report drinking soft drinks daily or more often compared to 19% of girls. Older children and those from lower social class groups are also significantly more likely to report drinking soft drinks daily or more often. There is an overall decrease in the proportion of children who report drinking soft drinks daily or more often from 2006.

Table 3.11: Soft drinks consumption among children by age, gender and social class (Kelly et al, 2012)

Soft drinks	Characteristics					
	Gender	Social Class (SC)	Age group (% in years)			
			10-11	12-14	15-17	All
	Male	1-2	10%	18%	21%	23%
		3-4	13%	23%	25%	
		5-6	18%	29%	33%	
	Female	1-2	10%	12%	14%	19%
		3-4	15%	19%	21%	
		5-6	21%	24%	26%	
	Both	All SC				21%

Soft drink consumption also varies according to mother's educational status. Children whose parents are educated to degree level or higher are significantly more likely to consume fewer soft drinks.

Table 3.12: Soft drinks consumption among children by age and mother's educational status (GUI, 2011; GUI, 2009)

Soft drinks	Characteristics		
	Mother's educational status	Age group (% in years)	
		3 years	9 years
	Lower secondary or less	41%	63%
	Degree or higher	24%	40%

Table 3.13: Soft drinks expenditure by gross household income decile in euro (CSO 2012e)

	Average €	1st[16]	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Soft drinks - not concentrated, not low cal	3.14	1.36	2.06	2.41	3.12	3.42	3.79	3.62	3.85	3.92	3.9
Soft drinks - not concentrated, low cal	0.69	0.32	0.42	0.56	0.7	0.72	0.77	0.74	0.84	0.88	0.97
Soft drinks - concentrated, not low cal	0.22	0.1	0.14	0.18	0.22	0.22	0.21	0.26	0.31	0.28	0.27
Soft drinks - concentrated, low cal	0.09	0.02	0.06	0.05	0.1	0.1	0.09	0.13	0.09	0.17	0.13
Pure fruit juices & pure fruit smoothies	1.45	0.6	0.66	0.95	1.21	1.45	1.32	1.64	1.71	2.31	2.69
Vegetable juices	0.01	0.01	0	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01
Mineral or spring water	1.04	0.41	0.49	0.62	0.95	1.17	0.98	1.33	1.3	1.38	1.81

Table 3.14: Soft drinks expenditure as proportion of total weekly expenditure by household income decile (CSO, 2012)

Beverage description	Characteristics Gross household income decile										
	1st 17	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	State average
Proportion of household spend on carbonated drinks - not low cal	0.38 %	0.54 %	0.50 %	0.54 %	0.52 %	0.49 %	0.40 %	0.37 %	0.32 %	0.22 %	0.39%
Proportion of household spend on carbonated drinks - low cal	0.30 %	0.16 %	0.17 %	0.18 %	0.16 %	0.14 %	0.13 %	0.12 %	0.11 %	0.08 %	0.12%
Proportion of household spend on all carbonated drinks	0.68 %	0.70 %	0.67 %	0.72 %	0.68 %	0.63 %	0.53 %	0.48 %	0.43 %	0.003 %	0.51%

The highest average weekly spend on any beverage was found for soft drinks - not concentrated and not low in calories (€3.14) followed by pure fruit juices and pure fruit smoothies (€1.45). Average household weekly spend increased with levels of affluence for

[16] First decile has lowest average income (<€238), tenth decile has highest average income (€2046).

[17] First decile has lowest average income (<€238), tenth decile has highest average income (>€2046).

all beverages except vegetable juices. More affluent households showed a higher 'absolute' average spend on soft drinks in general. This was also true for pure fruit juices and pure fruit smoothies. Data from the CSO 2009-2010 household budget survey (CSO, 2012e) found that households rented from a local authority had the highest proportional spend on soft drinks; 6.3% compared with 3.1% for households owned outright.
Data on the proportional spend of households by income decile highlights the trend in lower income households spending relatively more on all carbonated drinks compared to higher income households (see table 3.14). This trend is evident across both low calorie carbonated drinks and non-low calorie carbonated drinks. In the 2nd to 5th household income deciles, proportional spending on sugar sweetened carbonated drinks ranges between 0.50% of total household weekly income to 0.54%. In the highest 3 household income deciles, proportional household spend ranges between 0.22% and 0.37% of total weekly spend. In relative terms then, consumption of non-low calorie carbonated drinks is more concentrated in the lowest income households i.e. the less affluent portion of the Irish population, except for the poorest income decile. In terms of implementing a tax on SSDs, data illustrates that the greatest relative burden is likely to be borne by individuals living in the least affluent households, not the absolute poorest, but certainly not the most affluent.

Table 3.15 and 3.16 provide information from the Canadean market research report on the consumption of a range of beverages in Ireland 2005-2010. Estimated forecasts are provided for 2011-2014 for a range of beverages: carbonates, juice, nectars, squashes/syrups, Iced/RDT tea, sports drinks, energy drinks, still drinks and bottled water. Data are presented by amount of beverage consumed per million litres and also in litres consumed per capita. A summary account of overall consumption levels is presented below, followed by a detailed discussion of the current and emerging trends in the market for each beverage, as well as marketing approaches, pricing/valuation, packaging and distribution patterns.

Overall, there was a steady decline in the consumption of carbonated drinks, juice drinks, nectars and still drinks between 2005 and 2010, although consumption of all other beverages has increased during this period. While consumption levels are decreasing,

carbonated drinks continue to be the most consumed beverage in Ireland. In 2010, almost three times more carbonated drink was consumed (379.6 m/l or 83 litres per person) compared to the second most consumed beverage: bottled water (137.1 m/l or 30 litres per person). There was also a high consumption level of squashes and syrups in 2010 (128.7m/l). Consumption of sports drinks has decreased slightly since 2007 and consumption is forecast to remain at current levels in the next 3 years (3.0m/l), while consumption of energy drinks are expected to increase slightly in the same period.

Table 3.15: Consumption of beverages per million litres (m/l) in Ireland (observed data from 2005-2010 and forecast data 2011-2014) (Canadean, 2011)

	2005	2006	2007	2008	2009	2010	2011F	2012F	2013F	2014F
Carbonates	418.3	420.0	422.1	406.6	383.4	379.6	377.7	375.9	379.7	383.5
Juice	60.0	61.8	63.1	60.9	52.9	46.0	42.8	43.8	44.2	44.7
Nectars	7.5	7.7	7.7	7.7	7.2	6.6	6.5	6.3	6.2	6.2
Squashes/Syrups	108.3	110.6	114.3	112.3	115.6	128.7	135.2	137.8	140.5	143.4
Iced/RTD tea	0.4	0.7	1.0	1.3	1.1	1.0	0.9	0.9	0.9	0.9
Sports drinks	11.1	12.1	15.4	15.1	14.4	14.3	14.3	14.2	14.4	14.5
Energy drinks	31.6	32.3	32.8	32.1	32.2	32.9	33.6	34.4	35.1	35.8
Still drinks	27.9	30.3	31.5	30.6	27.0	25.8	25.1	25.3	25.5	25.8
Bottled water	122.4	140.8	156.9	147.7	133.0	137.1	134.7	132.2	133.5	134.9

Table 3.16: Consumption of beverages in litres per capita in Ireland (data 2011-2014 is forecasted) (Canadean, 2011)

	2005	2006	2007	2008	2009	2010	2011F	2012F	2013F	2014F
Carbonates	101.2	99.1	97.3	91.9	85.2	83.0	81.4	79.9	79.8	79.7
Juice	14.5	14.6	14.6	13.8	11.7	10.1	9.2	9.3	9.3	9.3
Nectars	1.8	1.8	1.8	1.7	1.6	1.4	1.4	1.3	1.3	1.3
Squashes/Syrups	26.2	26.1	26.3	25.4	25.7	28.1	29.1	29.3	29.5	29.8
Iced/RTD tea	0.1	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Sports drinks	2.7	2.9	3.5	3.4	3.2	3.1	3.1	3.0	3.0	3.0
Energy drinks	7.6	7.6	7.6	7.3	7.1	7.2	7.2	7.3	7.4	7.4
Still drinks	6.7	7.2	7.3	6.9	6.0	5.6	5.4	5.4	5.4	5.4
Bottled water	29.6	33.2	36.2	33.4	29.5	30.0	29.0	28.1	28.1	28.0

3.8 Current and emerging trends in the beverage market in the Republic of Ireland

Despite a challenging economic environment in recent years, soft drinks remain a strong industry in Ireland. All data presented in the following two sections are sourced from the Canadean research report (2011) with a detailed discussion of the current and emerging trends in the market for each beverage type. Data is presented on beverage type including sugar sweetened beverages and other beverages, however a focus has been applied to the market trends in sugar sweetened drinks. Actual data are reported for the

years 2005 to 2010 and forecasted for 2011 to 2014. Beverage and distribution definitions are provided in appendices 5 and 6.

Carbonated Drinks

Carbonates consumption declined by 1% in 2010, compared to a 6% decrease in 2009 at the height of the recession. The recession and the on-going weak economic situation in 2010 have made an impact on the entire beverage market, with the consumer being more budget-conscious. Poorer than expected summer weather may also be a factor in consumption trends. Innovation during 2010 was mainly through Private Label (PL) brands rather than the leading branded manufacturers. Price promotions and the supermarket price war have resulted in near price parity between soft drinks in Northern Ireland and the Republic of Ireland, which has brought about a waning in cross-border shopping.

The cola segment drives the market and accounted for 52% of the carbonates market in 2010. It grew by 2% in a declining carbonates market due to strong promotional activity for the major brands Coca-Cola and Pepsi-Cola and also for PL brands and the discounters Lidl and Aldi. Both Coca-Cola and Pepsi-Cola brands showed positive growth in 2010. The lemon-lime segment achieved only flat growth in 2010, with 7-Up performing better than Sprite. There was negative growth in the orange segment in 2010; down by 6% on 2009.

Low calorie accounts for about 25% of the total carbonates market. There was growth of 7% for Coke Zero between 2009 and 2010. Diet Coke also showed slight growth but Pepsi Max had double-digit growth attributable to heavyweight advertising. In the lemon-lime low calorie segment, 7-Up Free managed flat growth but Sprite Zero suffered a substantial loss in volume. It is interesting to note that in Northern Ireland the low calorie segment accounts for a higher market share at around a third of total consumption.
Cola remains the dominant flavour driven by Coca-Cola and Pepsi-Cola. Lemon-lime flavour is the second largest segment, with 7-Up the market leader followed at some distance by Sprite. The orange flavour segment is the third largest, led by local brand Club from Britvic followed by Fanta. Regular carbonates account for around 75% of the total carbonates market.

In recent years, PL brands have achieved varying levels of penetration on a flavour by flavour basis; it is understandably limited in the cola segment, where the strong marketing support given to Coca-Cola and Pepsi-Cola acts as a barrier to expansion. However, the current economic climate has made PL and discounter colas more acceptable to consumers and this trend may continue into 2011. Lidl and Aldi, the German discounters, like the PL brands have taken advantage of the recession to promote low prices. The PL brands from the leading major multiples (Tesco, Dunnes, Superquinn) and the symbol chains also posed a threat to branded carbonates with their low prices.

Random store checks indicate that some supermarket prices rose very slightly in 2010, although the on-going supermarket price wars are tending to keep prices reasonably stable. Regular multi-pack (61cl-1000cl) offers create a value for-money platform and were heavily featured in store in 2010. The 200cl Polyethylene terephthalate (PET) bottle has become a strong promotional pack, with many twin pack offers and triple packs on promotion. Also the 33cl can in multipacks is doing well with attractive promotional prices for six and twelve packs in both supermarkets and some convenience stores.
It is expected that the current economic downturn in Ireland will continue to have a negative impact on the carbonates category in the coming years. The forecast is for a further decline in carbonates consumption of around 1%. The major companies are expected to continue promoting key carbonate brands strongly, in particular their cola brands as we have seen in the last few years of recession. There is no doubt that strong price competition will continue to come from discounters Lidl and Aldi and PL brands with lower priced carbonates offerings. It is expected that promotional activity will be especially focused on regular and low calorie colas.

Nectars

In 2010 consumption of nectars fell by 7%. Nectars growth has been impacted by the trend away from sugar-containing beverages but also due to a lack of innovation.

The ambient segment accounts for the bulk of consumption with over 90% of the market and chilled products remain a small niche. However, the ambient segment has become much more commoditised, with very competitive retail pricing. Cranberry remains the key

flavour. Blueberry and pomegranate products, also offering antioxidant benefits, have appeared in recent years but have not made much of an impact. Cranberry/mixed fruit drinks generally fall into the still drinks category due to their low juice content. Brand leader Ocean Spray is coming under threat from local brands like Fruice and Sqeez and from some minor brands and PL products. In the past few years the nectars category has seen innovation in PET bottles, with Tropicana Go (relaunched in 2009 as Tropicana Kids) and Fruice Juicy aimed at the school lunchbox market and 'on the go' consumption. Britvic Ireland launched a higher juice content variant of its Robinsons Fruit Shoot range in 20cl PET in 2010, in an effort to attract parents to buy the drink for their children as one of their five portions of fruit or vegetables each day.

Nectars prices remain extremely competitive through deep cuts and promotional activity, although unit prices have risen very slightly recently. Nectars purchases, like pure juice, are heavily biased towards the retail trade and at-home consumption. Consumption is forecast to decline by around 3% in the coming years. Although, given the current economic climate, there may be more switching away from juice towards nectars.

Still Drinks

In Ireland still drinks is segmented into traditional children's drinks segment and adult drinks segment. Still drinks sales have been weakened by the current economic situation, the niche adult segment in particular. Overall still drinks consumption was down by 4% in 2010. Some consumers may have switched to squash as a cheaper alternative during the recession. No added sugar (NAS) formulations like Club Source and Capri-Sun appeal to their respective adult and child/teenage audiences and have been quite successful in recent years as consumers cut back in general on sugary drinks. The children's segment is fiercely competitive, with major brands like Ribena, Robinsons Fruit Shoots and Mi-Wadi Juice Boost competing for the lunchbox trade in the major supermarkets.

Orange is the leading flavour and has sustained limited growth over the last few years and its share actually declined in 2010 in favour of new, more 'exotic' flavours. Consumption of blackcurrant and mixed fruit flavours have been increasing in the children's segment and mixed fruits are gaining momentum in the adult segment. NAS or

lower sugar formulations are becoming more prominent as a result of consumer demand for healthier drinks.

Still drinks are traditionally a value-for-money children's drinks market. In the recent past there has been increasing marketing focus on the adult still drinks market, where products can command more of a premium. The children's segment features strong competition between major brands like Capri-Sun, Ribena, Amigo, Mi-Wadi and Robinsons, with multi-pack offers and price promotions intensifying competition. Strong through the line marketing activity is helping to create and maintain brand distinction and difference despite the availability of PL brands with lower prices. Ribena (GlaxoSmithKline) has been particularly aggressive with price promotions in-store and strong advertising once again in 2010. Generally, prices have risen very slightly in some channels in the last year, although promotional activity, especially through multi-buy deals, ensures a competitive environment.

Manufacturers are attempting to drive up volume, particularly in the lunchbox market. In convenience stores and other impulse channels, chilled single-serve (<60cl) products are boosting 'on the go' consumption. On-premise prices are likely to be near double retail value. Still drinks are also expected to decline by around 3% in the coming years. Promotional offers and strong marketing may maintain market shares for the leading brands despite further pressure from PL brands and the discounters.

Squashes/Syrups

Squash/syrups are very popular in Ireland. In 2010, the category grew 11%, the strongest growth of any soft drinks category. Strong retail price promotions by the key brands and heavyweight discounting of PL brands and discounter products helped boost the category. Innovation has also played a significant role in growth, in particular the emergence of double concentrate squash. Orange remains the leading flavour with 44% of volume; this has declined from around 52% in 2000, as various mixed fruit combinations and other single fruits have gained ground. They have been revitalised in recent years by no added sugar (NAS) offerings from all the major manufacturers. NAS products now account for around 57% of all squash/syrups.

In recent years discounters Aldi and Lidl have been over-trading in the market at the expense of supermarkets and traditional retailers. Low margins deter a high level of marketing activity, although periodic media campaigns and point-of-sale displays are used by the major brands. Squash/syrups prices remain very competitive in the grocery trade with special offers; buy-one-get-one-free and ‘extra free’ promotions are quite commonplace.

Some 90% of all sales are made through retail outlets for home use, with no discernible movement in trend. On-premise usage is restricted by the nature of the product, but, besides institutional use, squash/syrups are sold as an accompaniment to spirits in the pub trade (known as a 'dash') and as an ingredient in milkshakes.

Canadean forecasts further growth of 5% for squash/syrups as the economy remains weak and consumer spending is restricted. There is an increased marketing trend towards NAS squash/syrups products and the leading companies continue to support their brands with strong advertising and promotional campaigns.

Sports Drinks

Sports drinks consumption declined by 1% in 2010 despite strong promotional activity from the major brands i.e. Lucozade Sport, Powerade and Club Energise Sport. The premium price of these drinks curtailed consumption as purchasing power remained low. PL brands have taken advantage of the economic situation with their low price offerings to grow market share. Although a relatively small category, there is a great deal of marketing support from the leading companies in order to maintain brand awareness. As well as above the line activity, sponsorship plays a key role in brand building, promoting associations with top players and teams. Coca-Cola HBC Ireland has a deal with the IRFU, supplying Powerade to the Ireland rugby squad. GlaxoSmithKline uses sports personalities - Ronan O’Gara, Damien Duff and Colm Cooper - in campaigns for Lucozade Sport. GlaxoSmithKline also sponsors the IRFU and the Dublin City Marathon as well as the Irish Basketball Association and the Professional Golfers’ Association. The Gaelic Players’

Association (GPA) is sponsored by Britvic Ireland, with 6% of net revenue from Club Energise Sport going to the GPA.

Average prices were fairly stable in 2010 thanks to a great deal of seasonal promotional activity, including 'extra free' fillings and multi-pack deals in the major multiples and leading stores. Prices, however, have already started to edge up since 2010. On-premise pricing, especially in fitness clubs and vending machines, is significantly higher than in grocery and CTN outlets (confectioners, tobacconists, newsagents). Over 90% of sales volume currently passes through retail channels, particularly supermarkets, symbol chains, convenience stores, petrol stations and CTNs, reflecting the 'on the go' nature of this category.

The sports drinks category is forecast to decline by around 1% in 2011 but the major brands are expected to maintain strong promotional activity, especially on multi-pack offers.

Energy Drinks

Energy drinks returned to growth in 2010, with consumption up by 2% due to strong promotional support for the major brands and growth coming from PL brands. There are two types of energy drinks competing in the market. Firstly, there is the traditional glucose-energy low caffeine containing drinks often referred to as the 'daytime' energy drinks. Secondly, there is the high caffeine, guarana and taurine containing energy drinks. Lucozade Original and its flavour variants continue to dominate the 'day-time' segment whilst Red Bull leads the 'night-time' segment.

Consumers have recently turned towards PL brands and also cheaper brands like Boost and Emerge in order to save money. Lucozade Alert is the first 'mental stimulation' positioned energy drink on the market. Red Bull Sugar Free leads the low calorie segment which, although growing, remains small. There is local production from the key players but also a small number of UK product imports. The energy shot drinks market took off in 2009 with the launch of Red Bull Energy Shot, followed by Lucozade Alert Plus in a 6cl PET bottle. Since then Relentless, Boost and a number of other energy shot brands have

entered the market in the 5/6cl PET bottle. These drinks are mainly distributed in 'on the go' outlets including petrol station forecourt shops and other convenience channels. However, overall volume for energy shots remains small, partially due to the price.

Strong marketing activity backed by heavy-weight promotional activity by the leading brands has been crucial in this category. Average retail prices edged up slightly in 2010 but there were considerable multi-pack offers and 'extra fill free' promotions from the major brands to try and off-set price rises. Major brands like Lucozade, Red Bull, Club Energise and BPM are slightly cheaper in the major multiples than in the symbol chains and the CTN outlets, where impulse purchases are more common and the convenience of 'on the go' is perhaps slightly more important than price. PL brands have also been offering multi-packs, at much lower prices than the leading brands. Energy drinks in the on-trade command a hefty premium compared with supermarket prices. Red Bull in particular is around double the price in pubs compared with a typical supermarket or convenience store. In on-premise outlets an energy drink like Red Bull enjoys the duality of function as both mixer and a straight drink. The energy drinks market is expected to show further growth of around 2% even though the economy is still fragile; constraints on disposable income may force many consumers to seek cheaper alternatives in the form of low priced energy brands (such as Boost) or PL brands.

3.9 Leading beverage companies, market value and distribution patterns

Leading companies have a majority share of all beverage markets. Table 3.17 provides a breakdown of market share by leading companies compared to total share by all other companies. The two leading companies, CCHBC and Britvic Plc, maintain a good level of advertising and marketing support for their respective brand portfolios. They strive to maintain image and resist threats from PL brands and some of the local independents who are attempting to gain market share. Marketing focus has been on core brands: innovation was restricted in 2010 as the companies focused on their core brands during the recession.

Table 3.17: Total share of beverage market by leading companies and others in Ireland 2010 (Canadean, 2011)

	Carbonates	Juices	Nectars	Squashes/ Syrups	Iced/ RTD teas	Sports drinks	Energy drinks	Still drinks	Bottled water
Total share by leading companies	89.4%	45.1%	90.2%	79.1%	100%	83.1%	89.5%	67.2%	72.5%
Total share by all others	10.6%	54.9%	9.8%	20.9%	0%	16.9%	10.5%	32.8%	27.5%
Barry's Tea		14.7%	12.5%					10.1%	
Britvic	9.5%	2.8%		58.2%		6.9%	2.2%	9.9%	21.3%
CCHBC		9.6%	14.3%	5.0%					15.6%
Coca Cola	54.4%			8.6%		14.6%	2.7%	5.8%	
Danone Group									13.6%
Glaxo Smith Kline				7.3%		60.7%	61.3%	19.0%	
Gleeson Group	5.3%								18.3%
Kerry Foods		4.0%							3.6%
Nestle					99.1%				
Ocean Spray			59.3%						
Pepsi-Co	20.1%	14.0%	4.2%			0.9%			
Red Bull Trading							23.4%		
Suntory Holdings	0.0%				0.9%				
Wild								22.5%	

Pricing/valuation

Random store checks indicate that supermarket beverage prices rose very slightly in 2010, although the on-going supermarket price wars are tending to keep prices reasonably stable. Regular multi-pack offers create a value-for-money platform and were heavily featured in store in 2010. The 200cl PET bottle has become a strong promotional pack, with many twin pack offers and triple packs on promotion during the year. Also the 33cl can in multipacks is performing well with attractive promotional prices for six and twelve packs in both supermarkets and some convenience stores.

Market value

Table 3.18 provides information on the breakdown of market value for each category of beverage. Clearly, carbonated drinks are the market leader with a market value of €873.32

million in 2010. Energy drinks have claimed a significant share in the market since their introduction reporting a value of €291.37 million in 2010. Leading companies such as Coca-Cola and Britvic maintain a strong position in the beverage market with PL companies accounting for only a small proportion of market share.

Table 3.18: Market value of soft drinks by category in Ireland 2010 (Canadean, 2011)

	€million	€/Litre
Carbonates	873.32	2.30
Juice	96.38	2.10
Nectars	14.10	2.14
Squashes/Syrups	59.72	0.46
Iced/RTD tea	2.98	3.12
Sports drinks	44.54	3.11
Energy drinks	291.37	8.84
Still drinks	51.03	1.98
Bottled water	195.25	1.42

Packaging

PET drives the carbonates market and the 200cl bottle reigns in driving market volume. Single-serve PET, especially 35cl and 50cl, are popular for 'on the go' consumption. Although the 35cl PET pack has edged back in volume in the last year or so, it remains an ideal pack size for the impulse channels, offering affordability. Can market share is driven largely by a retail emphasis for multi-packs on promotion. Canned packaging is therefore fighting back against competition from single-serve PET.

Distribution

The proportion of beverage sales by distribution type (off-premises or on-premises) is presented in table 3.19. Between 72.6% and 95.6% of total beverage sales are sold for off-premises consumption i.e. sold for 'subsequent consumption' away from the place of purchase. This includes sales in supermarkets, convenience stores, pharmacies and off-licences. Energy drinks have the highest proportion of on-premises sales i.e. sold for 'immediate consumption' at the place of purchase. This includes vending machines, EDA (Eat, Drink and Accommodation) establishments, institutions (for example, workplaces, hospitals, universities) and other venues such as cinemas, leisure facilities and gyms. Almost one fifth of all carbonates (17.8%) are also sold on-premises. Further breakdown of beverage sales forecasts are presented in table 3.20 by distribution category.

Table 3.19: Distribution of soft drinks by category in Ireland 2010 (Canadean, 2011)

	Off-premises	On-premises
Carbonates	82.2%	17.8%
Juice	95.6%	4.4%
Nectars	88.4%	11.6%
Squashes/Syrups	93.3%	6.7%
Iced/RTD tea	92.1%	7.9%
Sports drinks	92.7%	7.3%
Energy drinks	72.6%	27.4%
Still drinks	92.9%	7.1%
Bottled water	92.1%	7.9%

The recession has taken its toll on the on-premise sales of all SSDs. Over 80% of carbonates are sold through off-premise channels, of which major multiples have a strong market position. In the major supermarkets, multi-pack offerings are a common feature. Manufacturers of still fruit drinks are attempting to drive up volume, particularly in the lunchbox market. The majority of sports and energy drinks sales volume currently passes through retail channels, particularly supermarkets, symbol chains, convenience stores and petrol stations.

Table 3.20: Trends in distribution of soft drinks sales per million litres in Ireland 2010-2012(forecast) (Canadean, 2011)

	2010	2011	2012F
Total soft drinks	772	756.4	749.5
Off premises	670.3	658.5	652.9
Modern Retail	545.0	537.9	533.6
Large Modern	545.0	537.9	533.6
Traditional Retail	123.3	118.8	117.5
Specialist Beverage Retailer	2.0	1.9	1.8
On-Premises	101.8	97.9	96.6
Vending	5.4	5.3	5.1
Quick service restaurants	14.6	14.4	14.2
Eating, drinking and accommodation places	77.5	74.9	74.0
Other On-Premise (Cinemas, Street stalls, Kiosks)	4.2	3.4	3.2

4. Literature Review

4.1 Abstract

The literature review undertook a broad approach to consider published research in this area, and principally concentrated on obesity as the main health impact of concern, however ill-health related to obesity as well as dental health impacts are also briefly considered. After discussing the causes of excess weight gain and associated health risks the review also considers links between sugar sweetened drinks (SSDs)[18] *and obesity, taking into brief account some of the literature relating to physiological mechanisms through which SSDs may contribute to excess weight gain. Literature considering the effectiveness of SSD taxation and potential economic impacts are briefly explored. The review also considers systematic reviews and meta-analyses in this area. The review concludes that, much as with research in other fields, there are limitations in the current literature and conclusive answers are not available. Research in this area has been criticised for lacking methodological rigour, but with more rigorous studies demonstrating stronger evidence of SSDs links with weight gain. Although there may be a growing body of evidence implicating SSDs in excess weight gain, currently research in this area provides imperfect knowledge, which is further hampered by a lack of available information on consumer behaviour in response to a SSD tax. Reducing SSD consumption has the potential for improved health outcomes, but not if consumers switch to equally unhealthy or more unhealthy foods or drinks.*

4.2 Introduction

The principal questions that guide this review are:

- Does literature in this area demonstrate any links between SSDs and health impacts?
  These impacts could be positive or negative, and the definition of a health impact is broad to encompass the wider determinants of health.
- Does literature in this area provide any evidence that fiscal policies can influence health outcomes?

[18] The term sugar sweetened drink (SSD) or sugar sweetened beverage (SSB) is used throughout to refer to drinks with added sugar.

The chief health concern that such a tax is intended to target is obesity. The literature reflects this in concentrating on obesity as being the principal public health focus of fiscal policies in this regard. This review discusses obesity and potential associations with SSDs and also considers fiscal policies' role in changing consumption habits. The review concludes with an overview of systematic reviews in this area, and a brief note on potential economic impacts.

4.3 Methods

The literature review search strategy began with trying to identify other HIAs that dealt with SSDs; the only HIA that came close to this area identified was a Californian HIA for calorie-labelling of restaurant menus (Simon et al, 2008). Literature was then searched for systematic reviews, randomised controlled trials (RCTs), intervention studies, observational studies and modelling analysis in peer-reviewed journals where SSDs and obesity and obesity associated illnesses, as well as dental health were considered. Initial searches demonstrated a wealth of information was available on this topic, and as literature was reviewed a snowballing technique was used by checking reference lists. IPH received instructions to chiefly address obesity in the review as this is the principal issue that the proposed tax would intend to address. Systematic literature reviews are not frequently used in HIA as they can take many person-months or years to complete and require resources and capacity not generally available to those conducting HIA (Mindell et al, 2006). However, systematic literature reviews undertaken by others in this field were identified and are included in this review; when strict exclusion criteria were applied in these published reviews there were very few studies that could be included. These reviews tend to consider few aspects in a very detailed way, for example if there are relationships between satiety and weight gain for SSDs whereas a broader approach encompassing many aspects of a SSD tax was considered desirable for this HIA literature review. The decision was taken that a systematic review was too narrow for the task at hand, and that the snowballing technique would be preferable although it would also be limited by only being able to search for literature available in English. Cautionary notes must be made when considering available research. The principal obstacle is establishing causality which is an onerous task when dealing with populations rather than laboratory based and contained experiments; the problem of methodological rigour is also an issue,

for example, self-reported heights and weights may bias results and estimates of weight reduction frequently do not account for metabolic changes – weight loss does not have a consistently downward trajectory in a linear relationship with energy reduction.[19] Modelling is frequently used, and analysis of this nature is only as robust as current knowledge and assumptions are used to account for variables where data is unavailable. Modelling must be treated with caution due to these assumptions and uncertainties. In addition, it should also be remembered that evidence from the U.S. may not transpose to Europe as the U.S. is more reliant on high-fructose corn syrup (HFCS) for its sugar content rather than sucrose[20] as is the case in Europe, though this may be changing. A small number of included studies declared industry funding; authors funded by industry declared their independence and lack of interference by funding bodies.

4.4 Overweight and Obesity: measurement and causes overview

The WHO defines overweight and obesity as excessive fat accumulation that may impair health. Adult weight and obesity rates are most commonly expressed using the Body Mass Index (BMI). The BMI is a proxy for the ideal method of measuring excess body weight which would be to measure adipose tissue. BMI is an easier albeit more crude, method to calculate; weight is divided by height. In adults a BMI over 25 indicates overweight scaling upwards to morbidly obese.[21] Childhood risk of overweight and obesity is calculated differently as children are still growing and therefore they are charted in terms of percentiles within age group. Therefore, children are measured against their peers.[22]

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[19] The composition of weight loss depends nonlinearly on the body fat mass which also depends on age, sex and body weight. Thus calorie-to-weight loss conversion (3500 calories to one pound of weight) is not a constant. Also, the energy requirement of the body is determined by body weight among other factors; as body weight decreases so does the energy requirement. This dynamic relationship means that a constant rate of weight loss would require an ever increasing reduction of energy intake over time. For a constant reduction of energy intake, weight loss slows and a body-weight plateau is eventually reached. (Lin et al, 2011:338).

[20] These may not necessarily have different impacts on the body, but the fact that they are different should be noted.

[21] For information on cut off points see: http://apps.who.int/bmi/index.jsp?introPage=intro_3.html Accessed July 2012.

[22] In children, BMI is often calculated as a z-score; the number of standard deviations by which a child differs from the mean BMI of children of the same age and gender. (de Ruyter et al, 2012b). BMI z-scores are also often used within studies for adult samples.

As outlined in the population profile, overweight and obesity are becoming increasingly prevalent in Ireland. The causes of overweight and obesity are multifactorial, and blame cannot be apportioned to one particular cause. Foresight developed a comprehensive map outlining the complexity of obesity.[23] Principally, nutrition and physical activity are the two broad categories under which overweight and obesity can be considered; too much of one, too little of the other. Swinburn et al (2011) argue that the availability of cheap energy-dense food, alongside increased mechanisation and motorisation, and economic transition in tandem with its associated demographic transitions leads to the non-communicable disease burden of obesity. Figure 4.1 outlines a framework for obesity determinants while also outlining where policy interventions and health promotion programmes are best placed to have the most effect, but may also be the most difficult to implement (Swinburn et al, 2011). Policy interventions may have the greatest impact on the population, but are also the most politically difficult compared to health promotion programmes and medical services.

[23] http://webarchive.nationalarchives.gov.uk/+/http://www.bis.gov.uk/foresight/our-work/projects/current-projects/tackling-obesities/reports-and-publications [Accessed 30 July 2012].

Figure 4.1: A framework to categorise obesity determinants and solutions (Swinburn et al, 2011:808)

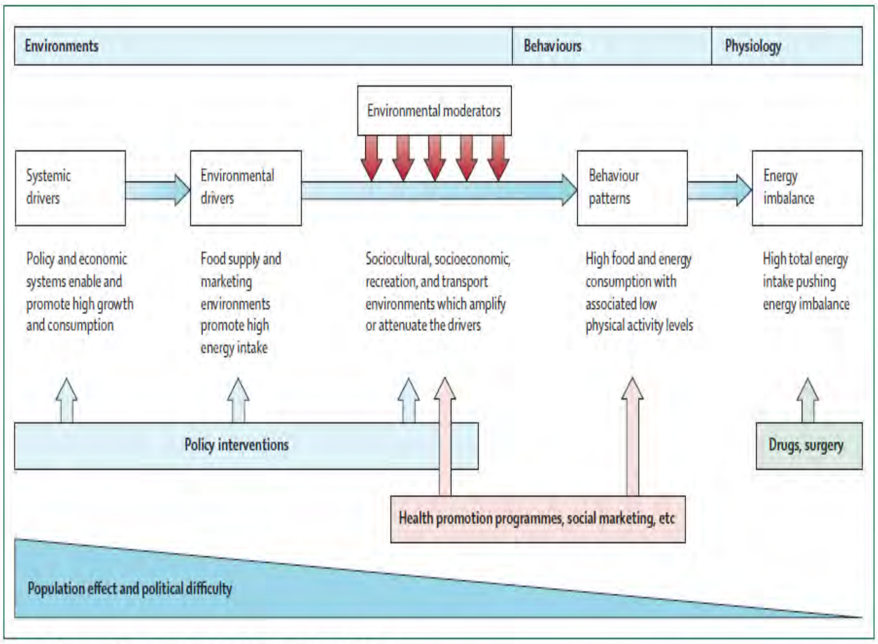

Figure 4: **A framework to categorise obesity determinants and solutions**
The more distal drivers are to the left and the environmental moderators that have an attenuating or accentuating effect are shown, along with some examples. The usual interventions for environmental change are policy based, whereas health promotion programmes can affect environments and behaviours. Drugs and surgery operate at the physiological level. The framework shows that the more upstream interventions that target the systemic drivers might have larger effects, but their political implementation is more difficult than health promotion programmes and medical services.

There are genetic predispositions to overweight and obesity which may be particularly susceptible in obesogenic environments. Kopelman (2007) states that body weight is determined by an interaction between genetic, environmental and psychosocial factors acting through the physiological regulation of energy intake and expenditure. McCarthy et al (2006) analysed available data from the North-South Ireland Food Consumption Survey (1997-1999) using a sample of 1,150 respondents. This cross-sectional, randomised representative sample had their weight, height and waist circumference recorded while they also maintained a 7 day food diary. Twenty-eight food groups were generated for logistic regression analysis; the strongest association with obesity occurred with savoury snacks, butter and full fat spreads. However, consumption of ‘high calorie’ beverages compared to ‘low calorie’ beverages was associated with a 3.9 times increased likelihood of being obese rather than of normal weight. McCarthy et al (2006) concluded that a combination of foods as well as lack of portion control were among the main reasons for overweight/obesity rather than one individual food group. Qi et al (2012) analysed the interaction between genetic predisposition and the intake of SSDs in relation to BMI and

obesity risk in 3 large US based datasets. Qi et al (2012)[24] concluded that the genetic association with adiposity appeared to be more pronounced with greater SSD intake. In all 3 datasets, the combined genetic effects on BMI and obesity risk among consumers of 1 or more SSDs per day were approximately twice as large as those among those who consumed less than 1 SSD serving per month. This may mean that; increased SSD consumption might contribute to obesity by interacting with a genetic predisposition to elevated BMI, or it could mean that people with a greater genetic predisposition may be more susceptible to obesity-inducing effects of SSDs.

Therefore, the origins of overweight and obesity are complex, going beyond diet, and even within the study parameters of diet the issues are complicated.

4.5 Health Risks of Overweight and Obesity

Table 4.1: Health risks associated with increasing BMI (abbreviated; Kopelman, 2007:14)

Health risks associated with increasing BMI	
Metabolic syndrome	30% of middle-aged people in developed countries have features of metabolic syndrome
Type 2 diabetes	90% of type 2 diabetics have a BMI of >23 kg m-2
Hypertension	5 x risk in obesity 66% of hypertension is linked to excess weight 85% of hypertension is associated with a BMI >25 kg m-2
CAD and stroke	Dyslipidaemia progressively develops as BMI increases from 21 kg m−2 with rise in small particle low-density lipoprotein Obesity is a contributing factor to cardiac failure in >10% of patients Overweight/obesity plus hypertension is associated with increased risk of ischaemic stroke
Respiratory effects	Neck circumference of >43 cm in men and >40.5 cm in women is associated with obstructive sleep apnoea, daytime somnolence and development of pulmonary hypertension
Cancers	10% of all cancer deaths among non-smokers are related to obesity (30% of endometrial cancers)
Osteoarthritis	Frequent association in the elderly with increasing body weight – risk of disability attributable to OA equal to heart disease and greater to any other medical disorder of the elderly
Liver and gall bladder disease	Overweight and obesity associated with non-alcoholic fatty liver disease and non-alcoholic steatohepatitis (NASH). 40% of NASH patients are obese; 20% have dyslipidaemia 3× risk of gall bladder disease in women with a BMI of >32 kg m−2; 7× risk if BMI of >45 kg m−2

[24] Study strengths included; prospective design, large sample, use of repeated measures of SSDs and BMI, comprehensive coverage of the established BMI associated genetic factors and the replication of results across cohorts. Limitations included that the proportion of the total energy intake derived from SSDs was not evaluated. Other limitations are listed, but authors have addressed these, for further information see Qi et al, 2012:9.

Genetic, environmental and psychosocial factors influencing body weight have combined to create obesity as a global public health concern. Table 4.1 outlines just some of the health risks associated with overweight and obesity.

Choudhary et al (2007) in their study of diseases associated with childhood obesity state that obesity causes serious complications in nearly every organ system. For example concurrent with table 4.1, Choudhary et al (2007) state that paediatric metabolic syndrome includes factors such as insulin resistance and hypertension, and is present in almost half of all severely obese children. This risk increases with BMI, and Choudhary et al (2007) are particularly concerned with the problems of radiographic imaging of obese children demonstrating the knock-on and unaccounted effects of obesity. Obesity at age 5 is a good indicator of obesity in adolescence (Angbratt et al, 2011) and beyond which is concerning given the recent Growing-Up in Ireland overweight and obesity data for the 3 year old cohort (2011). Three years is a very short space of time to have gained such excessive weight and does not bode well for future health outcomes. In addition to concern for young children, within-group dynamics also require examination. Sjönberg et al (2011) highlight the social gradient of obesity among Swedish children, while noting that non-Nordic origin is also associated with childhood obesity; in other words, that children from low-income backgrounds (which are likely to include ethnic minorities in a given country) may be particularly vulnerable to obesity risk. Using the same sample, Magnusson et al (2011) also note that health promotion interventions resulted in positive diet and weight changes, in particular among girls, in a low income multi-ethnic community. This research highlights the importance of considering gender and the sociocultural context of obesity in high risk communities, again reiterating the multiple factors that influence obesity.

In sum, although excessive weight gain from the diet, among other factors, leads to overweight and obesity and potentially serious health consequences, the role of sugar in obesity, and other non-communicable diseases, must now be explored. This review now focuses on literature with regard to SSDs for relevance, although there may be material on sugar in other food/drink sources and the relationship to health that have been excluded.

4.6 Sugar Sweetened Drinks (SSDs) and Health

There is scant evidence of any nutritional benefits to sugar consumption, although it may not be inherently problematic in moderation. Bachman et al (2006) outline 4 main mechanisms through which it is hypothesised that SSDs could lead to obesity;

Accumulation of total caloric intake, including SSDs increases obesity risk.

Glycemic index/load from SSDs exacerbates circulating insulin and adiposity risk.

'Liquid calories' induce lower satiety which leads to higher caloric intake.

The consumption of SSDs displaces milk in the diet, decreasing calcium intake that has obesity-lowering properties.

Bachman et al (2006) undertook a review of studies relating to each of these and concluded that the strongest evidence supports the excess calorie intake hypothesis although a number of studies showed no association. Bachman et al (2006) also note that assessing the contribution of one food group to obesity is a difficult task, because energy balance is a function of the total caloric intake and expenditure (see also McCarthy et al, 2006).

SSDs are hypothesised to appear in the diet as 'liquid calories'; in other words they are energy-dense products that are consumed but may not satiate appetite meaning that at the next meal or snack there is not a proportionate reduction in food intake to account for the liquid calories (Brownell et al, 2009). This can lead to excessive calorie consumption and overweight/obesity if it is a regular occurrence. SSD consumption could lead to obesity because of imprecise and incomplete compensation for energy consumed in liquid form (Ludwig et al, 2001). How this might occur is discussed in DiMeglio et al (2000) and the relevant text is in appendix 8. Bachman et al (2006) state that evidence in this regard is conflicting and note that other factors influence satiation such as palatability, texture and viscosity. In discussions of this satiety issue, the work of DiMeglio et al (2000) is consistently cited, albeit with occasional criticism, but this work met inclusion criteria for many of the systematic reviews discussed below.

DiMeglio et al (2000) found in a small sample of human subjects (n=15) fed either sweets (jelly beans) or SSDs over eight weeks, that SSDs consumption led to greater food

compensation. DiMeglio et al (2000) assessed physical activity before and after the intervention[25] while diet records were obtained on random days throughout. The forms of carbohydrate were not perfectly matched in this study; the SSDs contained high fructose corn syrup while the jelly beans were high in sucrose where it was expected that the higher fructose product (i.e. the SSDs) should be more satiating.[26] Dietary responses were contrary to this expectation. Mirroring this, Mrdjenovic et al (2003) found that children age 6-13 years old (n=30) did not compensate for their SSDs consumption and therefore had excess energy intake and greater weight gain. In addition, children in particular can become accustomed to excessively sweet tastes and reject healthier foods leading to life-long unhealthy dietary patterns; this includes artificially sweetened beverages that may not incur the same body weight health impacts as SSDs (Brownell et al, 2009). Yang (2010) argues that artificial sweeteners encourage sugar cravings, dependence and sweet tastes enhance the human appetite, stating that unsweetening the world's diet may be the key to reversing the obesity epidemic (Yang, 2010:106).

Libuda et al (2009) review of causal relationships between soft drink consumption and excess weight gain in childhood also supports the contention that obesity is multifactorial but replacement of SSDs with noncaloric alternatives, though it is a promising approach, must be part of a broader strategy. The Libuda et al (2009) review states that the impact on childhood weight by SSDs seems to be induced by inadequate energy compensation after SSD consumption. Olsen et al (2009) undertook a similar review and agree with Libuda et al (2009) results that a high intake of calorically sweetened beverages appears to be a determinant of obesity however Olsen et al (2009) did not believe evidence was conclusive that this association is mediated via increased energy intake.

Maersk et al (2012) had differing results; this study included 47 overweight subjects given 1 litre of 4 different drink types for 6 months (a cola drink, an artificially sweetened cola drink, still mineral water, semi-skimmed milk) and the cola drinkers did reduce energy from other sources. However, overall the cola drinkers had the least advantageous results. The participants who drank the SSDs had higher relative changes in liver fat, skeletal

[25] This work has been criticised for not controlling for physical activity.
[26] As the authors had anticipated based on a glucostatic theory of hunger (DiMeglio et al, 2000:799).

muscle fat and visceral adipose tissue compared with the other three drinks. Dental hygiene instruction was given and supported by toothpaste among the SSD drinkers – no detrimental effects were found. This study also measured physical activity and usual diet to ensure that no other changes were taking place during the intervention period. This study is limited in terms of being unblinded, having a small sample size, and it does not provide information about fruit juices. Malik et al (2010) note that there is growing concern about excessive fruit juice intake; alongside some vitamins and nutrients they also have a high sugar and calorie content. However, Malik et al (2010) note that the evidence in this regard is still limited and further research is needed.

Sartor et al (2012) also undertook a small sample experiment whereby 11 lightly active, healthy and lean subjects with sporadic SSD consumption undertook a 4 week SSD supplementation (2 drinks per day). Increases in fasting plasma glucose and a trend in reduction of insulin sensitivity were the result alongside adipose tissue deposition. Authors concluded that 4 weeks of SSD supplementation shifted substrate metabolism towards carbohydrates, increasing glycolytic and lipogenic gene expression and reduced mitochondrial markers. In other words, it appears from this small study, and replication on a larger scale is needed, that regular SSD consumption increases fat gain, inhibits fat metabolism, increases blood glucose in the body and overall, changes the way muscles use food as a fuel, making muscle burn sugar rather than fats.

Brownell et al (2009) outline 4 long-term RCTs among children in the UK, Brazil, Boston and Chile where SSD consumption was discouraged, substituted with milk, or substituted with diet alternatives. In each trial, a non-significant[27] weight reduction was noted, but with significant results occurring for children who were overweight at the baseline. In the UK study,[28] students (7-11 years old) in the intervention group had a non-significant lower

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[27] 'Significance' refers to statistical significance; that the change did not occur by chance. A non-significant weight reduction is not the same as a solid evidence base of a relationship. This should be noted throughout where literature is cited as having a 'non-significant' result.

[28] This study is discussed later (James et al, 2007) as results were not sustained in the follow-up period since the intervention had been withdrawn. Non-significant results are explained in the previous footnote for cautionary interpretation.

[28] French, S.A. Hannan, P.J. Story, M. (BMJ USA, 2004 (4):389) criticised this study for, among lapses in methodological reporting, not establishing links between SSD reductions and weight loss, or providing an explanation for why the control group continued to gain weight.

BMI than the control group, but a significantly (7.7%) lower obesity incidence after one year (Brownell et al, 2009:1600). A Brazilian study of 9-12 year olds found that 9 months later no change in BMI was observed except for a non-significant lowered BMI among the baseline overweight children in the intervention group – and this was a significant result among overweight girls. When an intervention group of Boston high-school students received home deliveries of non-caloric beverages for 25 weeks no significant BMI change was recorded except among children in the baseline upper third of BMI. Replacement of SSDs with milk among Chilean children over 16 weeks had a non-significant outcome for percentage body fat albeit reduced, and a significant increase in lean mass. Ebbeling et al (2006:679) study with Boston high-school students (outlined above) concluded by noting that decreasing consumption of SSDs would be a promising strategy for the prevention and treatment of overweight adolescents. This Boston-based randomised pilot (Ebbeling et al, 2006) was singled out in a review of the evidence (Pereira, 2006) as being of high methodological quality.

Brown et al (2011) noted the negative impacts of SSDs on hypertension in 2,696 US and UK citizens (fieldwork 1998/9), while soft drink consumption has also been implicated in associations with asthma and chronic obstructive pulmonary disease among 16,907 adults in South Australia even when accounting for lifestyle and socio-demographic factors (Shi et al, 2012). Two large longitudinal cohort studies in the US, one with health professionals (N=42,000+) and one with nurses (N=91,000+) showed other health risks associated with obesity.[29] Schulze et al (2004) report that female nurses who consumed 1 or more servings of SSDs per day had almost double the risk of developing type 2 diabetes as the women who consumed less than 1 serving per month. Almost half this excess risk was accounted for by greater body weight. Increased risk of coronary heart disease (CHD) was also found among daily SSD consumers versus infrequent consumers. Increased weight did not explain all of this association; although it was partially attributable (see also Brownell et al, 2009). Schulze et al (2004) noted (and made statistical adjustments to account for) female nurses with high SSDs intake also tended to be less physically active, to smoke more and to have higher total energy intake than their counterparts. De Koning et al (2012) analysed similar data among US health professionals

[29] These datasets were also 2 of the 3 used by Qi et al (2012) as mentioned previously.

and found that participants in the top quartile of SSD intake had a 20% higher relative risk of CHD than those in the bottom quartile.[30] SSD consumption was also associated with adverse changes in blood lipids, leptin and inflammatory factors. Intake of SSDs among these health professionals was much lower than the general U.S. population but consumption of SSDs was associated with several unhealthy lifestyle traits at baseline (e.g. smoking, intake of alcohol) however the opposite was found with those who consumed artificially sweetened beverages. The US Health Professionals Survey was also used to consider the role of fructose and SSDs in experiencing gout (Choi et al, 2008). This prospective data showed a strong association between these sugar sources and an increased risk of gout in men. In their review of published studies, Malik et al (2010) suggest that SSDs may contribute to type 2 diabetes and cardiovascular disease risk in part by their ability to induce weight gain but an independent effect may also stem from high amounts of rapidly absorbable carbohydrates such as sugar.

These two large datasets (Schulze et al, 2004; De Koning et al, 2012) were again used to explore SSD consumption and the risk of pancreatic cancer (Schernhammer et al, 2005). The rationale for this study was based on SSDs potential links with diabetes and obesity; diabetes and a high glycemic load are possible risk factors for pancreatic cancer. No links were found with men but a modest link was found for women who have an underlying degree of insulin resistance (elevated BMI or low physical activity). It was expected that this association was due to residual confounding by obesity, but the influence of SSD consumption on pancreatic cancer remained unchanged after BMI adjustment. A prospective cohort study of 487,922 US citizens between the ages of 50 and 71 years old found no overall association of total added sugar or sugar sweetened foods and beverages and pancreatic cancer risk; however the influence of a pre-diabetic condition cannot be eliminated as impacting on the lack of association (Bao et al, 2008). However, a prospective cohort study of 60,524 people in Singapore did conclude that regular consumption of SSDs may play an independent role in the development of pancreatic cancer (Mueller et al, 2010).

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[30] Adjusting for age, smoking, physical activity, alcohol, multivitamins, family history, diet quality, energy intake, BMI, pre-enrolment weight change and dieting.

Ludwig et al (2001) in their study of 548 children over a two year period noted that for each can/glass of SSD each day, the likelihood of becoming obese increased 1.6 times. However, diet SSD consumption was negatively associated with obesity incidence. Ludwig et al were critiqued in editorials for this study.[31] In sum, criticism focussed on the over-simplification of the problem however the authors responded to these criticisms reiterating the literature on satiation and re-acknowledging the multifactorial nature of obesity. An educational intervention in the UK (Christchurch Obesity Prevention Programme in Schools), also known as the 'ditch the fizz' project, resulted in a modest reduction in carbonated drinks and a significant reduction in the number of children becoming overweight or obese, however these results were not sustained over the three-year follow up period (James et al, 2007).[32] Although not strictly comparable, a more broadly based intervention programme in New Zealand (the APPLE project) focussing on lifestyle and exercise to include discouraging SSD consumption, found continued benefits to the BMI of the intervention group of children two years later (Taylor et al, 2008). An Australian study of 268 children found that soft drink or cordial intake at age 8 was associated with excess weight gain 5 years later, and children who were overweight/obese at baseline but had acceptable BMI at follow-up consumed significantly less of these drinks than their overweight/obese peers at follow-up (Tam et al, 2006).

De Ruyter et al (2012a) undertook an 18-month trial with 641 primarily normal weight children (age 4-12 years), randomly assigning them to receive artificially sweetened drinks or a SSD. De Ruyter et al (2012a) concluded that masked replacement of an SSD with a sugar free beverage significantly reduced weight gain and body fat gain in healthy children. Ebbeling et al (2012), in the follow-up to the pilot randomised trial mentioned above, undertook a similar intervention with 224 overweight and obese adolescents. Ebbeling et al (2012) found that after a 1-year intervention to reduce the consumption of SSDs, the BMI increase in the experimental group was smaller than that of the control group. However this was not sustained at the 2-year follow up; possibly due to an increase

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[31] Correspondence in the same journal: Fishbein, L. and also Henry, J. and Warren J.
[32] French, S.A. Hannan, P.J. Story, M. (BMJ USA, 2004 (4):389) criticised the original study for, among lapses in methodology reporting, not establishing links between SSD reductions and weight loss, or providing an explanation for why the control group continued to gain weight.

in consumption of SSDs in year 2 among the experimental group, and/or due to efforts to eliminate SSDs among the control group – for example in schools.[33]

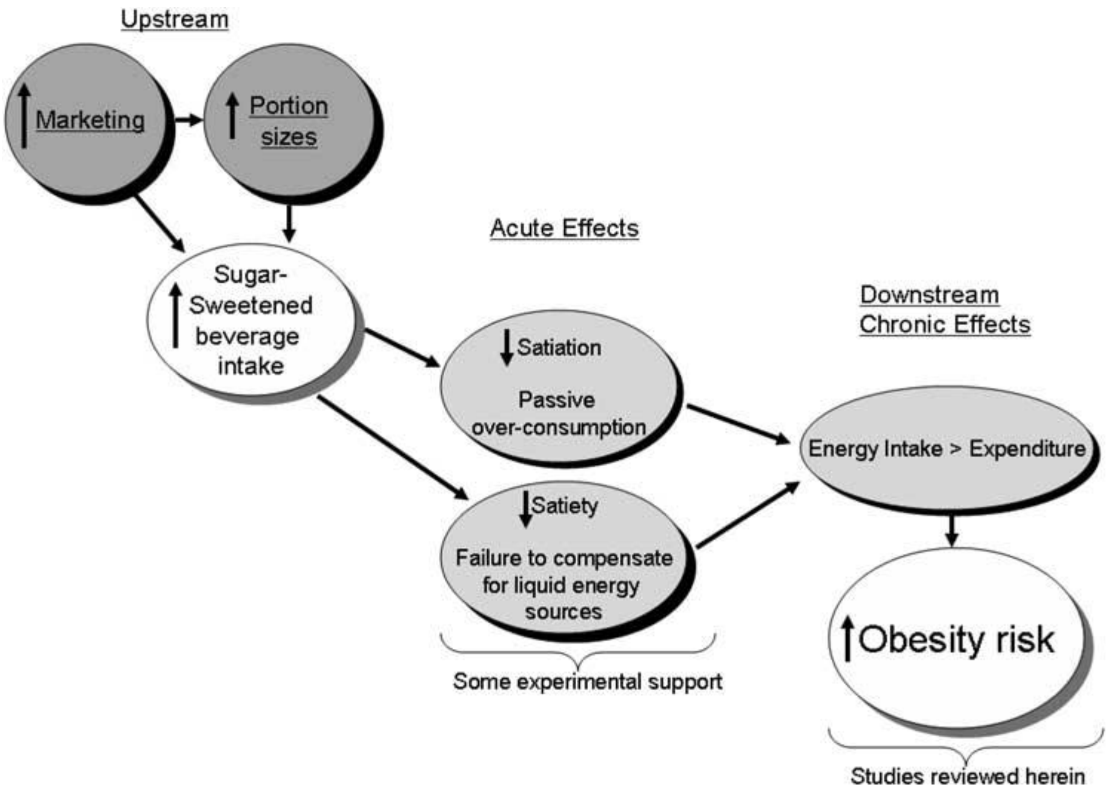
Vanselow et al (2009) in their 5 year longitudinal cohort of US adolescents (n=2,294) found no association between SSDs and weight gain, although adolescents who consumed little or no white milk gained significantly more weight than their milk-drinking peers. Vanselow et al (2009) note the variation in outcomes in the literature which makes conclusive statements on the contribution of SSDs to obesity difficult particularly with regard to research artefacts such as adolescents at different growth stages and self-reported consumption and quantities.

These links between SSDs and obesity etiology are difficult to establish in a robust way as Pereira's (2006) review of cross-sectional studies, prospective studies and RCTs explored. The framework guiding this review is outlined in figure 4.2. Pereira (2006) was unconvinced that SSDs are non-satiating, leading to no compensating calorie reduction, due to their high water content and volume. The chief complaint about studies in this area is that methodologies are flawed or not sufficiently scientifically robust. However, considering the outcomes of RCTs, which are the gold-standard of scientific research, Pereira (2006:S34) acknowledged there is growing evidence to date for the hypothesis that manipulating intake of SSB may cause important changes in habitual energy intake that could lead to increased obesity risk over an extended period of time. Pereira (2006) concludes that there are plausible mechanisms that may support a causal link between SSDs and obesity risk but the pathway that sets SSDs apart from its solid-food counterparts in this regard remains to be determined. The evidence may be probable rather than convincing, as the potential impact of recommendations to reduce intake of SSDs on obesity rates is difficult to predict (Pereira, 2006:S35). Weed et al (2011)[34] also criticise the methodological robustness of reviews in this area in their systematic review of quality of reviews on sugar sweetened beverages and health outcomes. The 17 reviews that met their inclusion criteria were assessed as receiving moderately low-quality scores

[33] Limitations include: self reported data, use of BIA to estimate body fat and small sample size.
[34] This study was funded by a beverage company. Authors assert their independence.

by the instrument used – AMSTAR; a one-page tool of 11 questions. They also note that the problem of rigour in published reviews is not confined to the issue of SSDs.

Figure 4.2: Theoretical framework for sugar sweetened beverages in obesity etiology (Pereira, 2006:S29)



Pereira's (2006) review mirrors evidence already outlined; that any links that may be found to exist between SSDs and obesity cannot be viewed in isolation, but rather that there are confounding effects. Regular consumption of SSDs may correspond to an already unhealthy diet and may particularly occur among population cohorts who are at a heightened obesity risk (for example, see Malik et al, 2010a).

Similarly, dental health researchers have not been able to prove definitively that SSDs lead to enamel erosion and dental caries. It is widely accepted that sugar is bad for the teeth so a direct relationship is recognised, but the damage may be limited by other factors in the developed world environment such as access to water for teeth-cleaning, and good brushing practices. A systematic review of sugar consumption and caries risk (Burt et al, 2001) demonstrated that where there is ample exposure to fluoride (i.e.

through drinking water), sugar becomes a mild to moderate risk factor for dental caries. Therefore, the role of sugar should not be the only focus in prevention of caries but excessive consumption of sugar should still be a consideration in dental health promotion (Burt et al, 2001). However, the WHO, through expert consultation, found the evidence for an association between free sugars, soft drink and fruit juice consumption and dental erosion and caries to be probable (WHO/FAO Joint Expert Consultation, 2003). In this same report, soft drinks were also considered as a probable cause of excess body weight among consumers, while links were also made between soft drink consumption and bone mineral density. This could be due to displacement of milk consumption in the diet in favour of SSDs and could have serious consequences for children and older women in particular (WHO/FAO Joint Expert Consultation, 2003). The Northern Ireland Young Hearts Project, in an observational study of 1,335 children aged 12-15 years old, found that higher intakes of carbonated soft drinks were significantly associated with lower bone mineral density in the heels of girls which could not be entirely explained by displacement of dietary milk consumption (McGartland et al, 2003). Keller et al (2009) similarly found in laboratory-based observations with young children that sweetened beverages replaced sources of calcium in a provided meal and intake of sweetened beverages increased with age while milk consumption declined. As mentioned, Mrdjenovic et al (2003) also found among a small sample of 6-13 year olds that excessive SSDs consumption (>12oz/day) displaced milk from children's diets although solid foods were not displaced. The consequence was lower daily protein, calcium, magnesium, phosphorus and vitamin A intakes. A recent national survey of children in Scotland (where water is not fluoridated) found that intake of SSDs had a positive association with tooth decay. This was particular to non milk extrinsic sugars, of which SSDs accounted for the highest proportion at 23%, not total sugars. This analysis concluded that increasing brushing frequency would not compensate for high intakes of non milk extrinsic sugars (Masson et al, 2010). The Irish Dental Association (November 2011) have called for public health warnings to be placed on soft drinks given Ireland's high per capita consumption and in light of data showing that half of all Irish 12 year olds and 75% of all 15 year olds have some decay in their permanent teeth.[35]

[35] [http://www.dentist.ie/resources/news/showarticle.jsp?id=1162 Accessed 4 May 2012].

4.7 Prices and Heath Outcomes

Taxation of foods/beverages deemed unhealthy is a policy option already implemented in many countries. These are commonly referred to as 'fat taxes' whereby fat content of food is subject to taxation. Whereas 'fat taxes' are problematic as this may lead to exclusion of co-occurring nutrients from the diet, this is not the case with most SSDs. For example, a fat content tax could lead full fat milk consumers to switch to lower fat milk, but it also has the potential for the reduction/exclusion of milk from the diet meaning a reduction in calcium with implications for bone density. In addition, it is recommended that infants drink full fat milk rather than low fat milk. As most SSDs do not contain useful nutrients, their exclusion from the diet is not a health concern. However, discouraging SSD consumption may lead to switching to other energy-dense products thereby neutralising the original intent, but it may also discourage consumption of co-consumed 'unhealthy' foods such as pizza or ready-meals (Allais et al, 2010; Duffey et al, 2010). In addition, discouraging SSD consumption may lead to behaviour changes among people who are occasional SSD consumers, but make no significant behavioural alterations among the target population cohort who should be reducing consumption considerably. Diet substitution is an important issue in considering taxation policy; consumers may select healthier options but they may also switch to products that may not be healthier, for example, a lower priced SSD or full fat milk that is healthier but may not reduce obesity (see Fletcher et al, 2010; Dharmasena et al, 2012). Dharmasena et al (2012) use a model considering demand inter-relationships between various beverages, to consider impacts of a 20% tax on SSDs.[36] While the consumption of drinks with added sugar are negatively impacted, the consumption of juices, low-fat milk, coffee and tea are positively affected. Interestingly, Dharmasena et al (2012) also note that diet soft drinks, high-fat milk and bottled water consumption decreases. These authors also estimate the body weight reduction to be between 1.54 and 2.55 pounds per year.

Price elasticity of demand has been defined as the way in which demand changes as a result of price changes, calculated as the percentage change in the quantity demanded

[36] Noted limitations of this study include limited to at-home consumption, the assumption of separability of non-alcoholic beverages from food and other beverage categories, and concentration on per-person basis rather than on children/above or below poverty individuals.

divided by the percentage change in price. Elasticities are always expressed as negatives and the 'more negative' elasticity is the smaller price increase needed to reduce consumption (Leicester et al, 2004). The average price elasticity of demand for soft drinks is estimated to be -0.79 (Andreyeva et al, 2010) whereby a 10% tax on SSDs could lead to a 8-10% purchase reduction and this is often cited in the literature albeit with the usual caveats for modelling exercises (see Fletcher et al, 2010; Finkelstein et al, 2010). It has been critiqued for not taking into account cross-price responsiveness (Edwards, 2011, 2012; Lin et al, 2011) while Lin et al (2011) state that there is evidence to suggest that the demand for SSDs is more price elastic than this range.

Duffey et al (2010) note that children, teenagers and older people are the most effected by price elasticity of tobacco and a similar pattern could be transferred to SSDs. Examining data from a 20 year longitudinal Coronary Artery Risk Development in Young Adults Study, Duffey et al (2010) found that an increase in the price of SSDs and pizza was associated with a significant decrease in daily energy intake from these products and lower body weight. Increasing the price of these two products had a greater than sum effect of increasing the price of one or other only. Lin et al (2011), similarly to Dharmasena et al (2012), noted that reduced consumption of SSDs is mirrored by diet drinks, which appears counter-intuitive, while demand for juice rises across all households. Demand for bottled water and lower-fat milk rises among high-income households. Epstein et al (2010) undertook an experimental laboratory based analysis of taxes and subsidies using energy and macronutrients purchased as dependent variables. These results suggested that subsidies made more money available for purchasing unhealthy products, while taxes were more effective in changing behaviours towards more healthy shopping baskets.

Duffey et al (2010) note that an 18% increase in SSD tax, as unsuccessfully (but with popular backing) proposed in New York, would have led to a 56kcal decline in the daily total energy intake among young to middle aged adults, which at a population level would have equated to 5lb per person per year weight loss and a significant reduction in obesity related diseases. Wang (2010) states this New York State tax would have prevented 3.5% of new cases of diabetes in men and 3% in women. However, Wang

(2010) also concedes that there is a dearth of empirical evidence on dietary substitutions in response to SSD taxation and that the equation for translating energy balance to weight change is controversial. Lin et al (2011) modelled tax-induced energy reductions from SSDs using static and dynamic calorie-to-weight models; demonstrating that static models overestimate weight loss. Over ten years the static model overestimates weight loss by 7.6 times over that of the dynamic model. Calculating weight loss without consideration of dietary substitutions is criticised by Edwards (2011; 2012) as already mentioned. A response to Edwards' criticisms (Braillon, 2012) notes that economic interventions are more effective than any other as they will not only change consumer behaviour, but also company behaviours. However both of these behaviours may be tempered by the wider policy space. Bonnet et al (2011) note that sugar market reforms will lead to a 36% decrease of sugar price in the EU and using French panel data (19,000 households 2003-2005 inclusive) performed a modelling exercise suggesting an increase in added sugar consumption of 124g per person where this increase is larger in households with overweight and obese individuals. The impact may vary across brands and rests on the assumption that the cost reduction will be passed on to the consumer, but Bonnet et al (2011) estimate a SSD price reduction of 3%, a 7.5% increase in consumption and an overall benefit to high sugar products. These authors recommend that taxation should be in relation to sugar content.

Fletcher et al (2009) in their analysis of US soft drink taxes and BMI found that although there is a statistically significant impact on behaviour and weight, the impact is small in magnitude. Further published work by Fletcher et al (2010), noting that soft drinks are the largest single contributor to energy intake in the US, undertook research using State soft drinks sales and excise tax information (1989-2006) and the National Health Examination and Nutrition Survey to examine if taxation impacted on energy intake this time particularly among adolescents and youth. This analysis suggests that soft drink taxation in the US leads to a moderate reduction in the soft drink consumption by youth but it is offset by increases in consumption of other high-calorie drinks such as juices or milk. However, these carry nutritional benefits albeit without addressing obesity. Fletcher et al (2010) conclude that a SSD tax to address obesity may be ineffective, however acknowledge in both studies that the data they are using are from states where the tax is

much lower than is proposed in modelling exercises. Higher rates of taxation could yield more beneficial results.

Chaloupka et al (2011a) modelled 4 different price changes; taxing SSDs only, and SSDs and artificially sweetened drinks at one US cent per ounce, and at two US cents per ounce. The optimal option for reducing obesity among the population, reducing diabetes occurrence, the healthcare cost of diabetes as well as costs associated with obesity-related healthcare was to place a two cent per ounce tax on SSDs only. However this was not the optimal method of revenue generation, placing a two cent per ounce tax across the soda market would have the best revenue outcome.[37]

Finkelstein et al (2010) note that a US 20% tax on all SSDs would lead to weight loss of 0.32kg per person (SE 0.09), while a 40% tax would lead to weight loss of 0.59kg per person (SE 0.16) assuming that food substitution does not occur and that weight loss is linear.[38] However, weight loss benefits accrue principally to middle income households. A 40% rate would equate to a per household financial cost of US$28.48 per annum. Finkelstein et al (2010) also note that lower income households purchase more SSDs but do so at lower average prices, and are more inclined to make these purchases in stores. Lower income households may be more sensitive to price changes but substitutions may occur to more generic, bulk or sale items or switching to non-taxed high calorie alternatives. If such a 20%-40% tax rate was introduced, and the revenue generated was put into obesity prevention measures, an even greater feedback loop may be the outcome. Lin et al (2010) similarly note that low income households are more likely to consume SSDs while high income households consume diet drinks, but that low income households in the US pay lower prices for all beverages due to quality differences, brand-level purchasing, economies of scale and neighbourhood effects. Lin et al (2010; 2011) conclude that although a SSD tax is more burdensome for low income households, it only represents about 1% of total food and beverage spending. The Institute of Fiscal Studies in the UK (Leicester et al, 2004) particularly note that 'fat taxes' are regressive as they will

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[37] The weight loss modelling was linear, and therefore subject to the caution highlighted throughout this review.

[38] The weight loss modelling was linear, and therefore subject to the caution highlighted throughout this review.

always absorb a greater proportion of low income households' incomes no matter how they are implemented. However they are more likely to succeed if unhealthy foods (e.g. SSDs) rather than blanket 'fat taxes' are introduced. They are also likely to garner more public support and acceptability if the revenue is ring-fenced. This echoes studies in New York which found a high level of popularity for introducing a SSD tax, as mentioned above, but that popularity increased exponentially (by 20%) when it was suggested that the tax be reinvested for obesity prevention (Brownell et al, 2009a).

Jou et al (2012) reviewed the application of a SSD tax for obesity reduction in 19 countries to assess factors that may influence policy effectiveness in country-specific contexts. Jou et al (2012) noted 3 key points that may influence the effectiveness of a volume-based excise tax; population obesity prevalence, SSD consumption levels, and existing baseline tax rates. Data suggests that where the obesity prevalence and SSD consumption rates are high, such a tax would be more effective. However, where the baseline tax rate is already high, there may not be a noticeable impact on consumption patterns or obesity prevalence and there may also be negative feedback from the public and industry. Jou et al (2012) caution that Ireland (among others) should be mindful that a volume-based excise tax would not undermine the existing price based tax, and should also be sure that the efforts to implement are justified against the benefits. Ireland already has a high tax on SSDs, so consumption may not be altered.

4.8 Systematic Reviews and Meta-Analysis

A small number of key meta-analyses and systematic reviews that were repeatedly identified in the literature are discussed in this section; focussing on the impact of SSDs on health, and fiscal policies and their potential to influence health.

Malik et al (2006) searched cross sectional, prospective and experimental studies to examine if a clear association between SSDs and weight gain exists. Thirty publications were identified that met the criteria and are discussed based on their research design.[39]

[39] *Inter alia* English language, endpoints evaluating body weight or size measurements, duration of 6 months or more for prospective cohort studies. A meta-analysis was attempted but was not feasible given the heterogeneity among studies.

Fifteen of these studies were cross-sectional, with 13 involving children and adolescents. Six of these 13 cross sectional studies with children and adolescents found a significant association between the intake of SSDs and overweight/obesity. Three studies had non-statistically significant positive associations while a further 3 found no association and one had inconsistent findings. Two of the cross sectional studies considered by Malik et al (2006) were with adults. These 2 studies found a greater probability of being heavier/overweight/obese for subjects who drank 1 or more SSDs per week that those who drank less than 1 a week, but in one of the studies significance was not established.

Malik et al (2006) also considered 10 prospective cohort studies; of which 6 were with children and adolescents.[40] Of these 6, 4 found positive associations between the intake of SSDs and greater overweight/obesity. The 4 studies showed that higher consumers tended towards overweight/obesity above the low consumers, but this was statistically significant in just 2 of the 4 studies. Two studies with children found no statistically significant associations between the intake of SSDs and BMI.

Three short term feeding trial experimental studies were considered by Malik et al (2006)[41] and all supported the hypothesis that the intake of SSDs is significantly associated with weight gain and obesity. Malik et al (2006) also considered two randomised control trials already discussed.[42]

Malik et al (2006) conclude that they believe the results of their systematic review support a link between the consumption of SSDs and the risk of overweight/obesity.[43] However, the authors state that interpretation of these studies is complicated by several method-related issues, including small sample size, short duration of follow-up, lack of repeated

[40] This included Ludwig et al (2001), Schulze et al (2004) already mentioned.
[41] This included DiMeglio et al (2000) already mentioned.
[42] James et al (2004) and Ebbeling et al (2006). Ebbeling et al (2006) has already been mentioned as finding that decreasing SSDs has a beneficial effect on body weight. James et al (2007) has been mentioned already, but Malik et al (2006) are referring to the original RCT which noted that reducing the consumption of carbonated beverages was associated with a reduction in the prevalence of overweight/obesity. However, the later paper (2007) reviews this programme and noted that the intervention did not have sustained results in follow-up.
[43] While also acknowledging the potential diabetes risk identified in one of the reviewed studies and other health risks identified in the literature but not part of the review (e.g. pancreatic cancer, hypertension, displacement of nutrients from the diet, bone density, dental caries).

measures in dietary exposures and outcome and confounding by other diet and lifestyle factors. Malik et al (2006) found significant relationships ($p<0.05$) in 14 of the 30 studies and one of these has been shown to not have sustained results in follow-up (James et al, 2007). Gibson (2008) criticises Malik et al (2006) for discussion of positive results as being synonymous with significance, as well as including two studies which were confounded by using diet soft drinks. Malik et al (2010) later undertook a review of SSDs, obesity, type 2 diabetes and cardiovascular disease risk. In considering the links between SSDs and weight gain, it is noted that it is difficult to disentangle the independent effects of SSDs when diet and regular soft drinks are included in a study; consumers of diet drinks may be weight-conscious. While acknowledging the low calorie benefits of these drinks, the authors raise concerns over the long-term health consequences of artificial sweeteners. This publication was not identified as a systematic review however the authors note that of the research they considered studies with long duration and large sample sizes that do not adjust for potential mediators of effect (e.g. energy intake) report stronger and more consistent results. Malik et al (2010) concluded that SSDs may increase type 2 diabetes and cardiovascular disease risk independent of obesity.

In another publication, Malik et al (2010a) undertook a meta-analysis[44] that included 11 studies relating to SSDs and risk of metabolic syndrome and type 2 diabetes, concluding that in addition to weight gain, higher consumption of SSDs is associated with development of both these chronic illness types. Malik et al (2010a) note that SSDs association with increased risk of metabolic syndrome and type 2 diabetes is in part due to weight gain, but an independent effect may stem from the high levels of rapidly absorbable carbohydrates in the form of added sugars. Three prospective cohort studies with 19,431 participants and 5,803 cases of metabolic syndrome comparing the lowest quartile with highest quartile consumers found a 20% greater risk for metabolic syndrome. For the 8 prospective cohort studies (310,819 participants, 15,043 cases of type

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[44] To include the following studies already discussed: Schulze et al (2004), and later published work by De Koning et al (2012). Eight studies related to type 2 diabetes, 3 related to metabolic syndrome. Significant heterogeneity was noted among both type 2 diabetes and also the metabolic syndrome studies. Malik et al (2010:2480) note that meta-analysis can be less robust than individual prospective cohort studies and outline how they attempted to overcome problems associated with heterogeneity.

2 diabetes) the highest quartile consumers had a 26% greater risk of developing the disease than the lowest quartile of SSD consumers.

Vartanian et al (2007) undertook a meta-analysis of 88 studies and noted a clear association between soft drink intake and absence of dietary nutrients, increased risk of health problems, increased energy intake and body weight. The design of studies influenced these results; for example more robust designs (longitudinal and experimental, rather than cross-sectional) and those not funded by industry,[45] having stronger effect sizes. A relationship between soft drink consumption and energy intake was found across almost all studies considered. Of the 12 cross sectional studies, just one had mixed results and one had no significant effect.[46] It suggested that SSDs either stimulate appetite or suppress satiety. The 5 longitudinal studies and 4 long term experimental studies[47] all reported positive associations suggesting that dietary compensation did not occur and individuals were still consuming as many calories as if they had not consumed any liquid calories. In addition, many studies also showed that appetites increased with greater soft drink consumption. Similar results were available in the short term experimental studies except in 2 studies with mixed results dependent on other factors. With regard to soft drink consumption and body weight, results were more mixed, although overall a positive association between consumption and weight was found.[48] Mixed results were mainly due to multiple ways of measuring weight. In considering both the interactions of soft drinks and body weight as well as energy intake, the effect sizes were largest for; women, adults, studies focussing on SSDs and studies not funded by the food industry.

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[45] Lesser et al (2007) undertook a review of interventional studies, observational studies and scientific reviews on soft drinks, juice and milk (published January 1999-December 2003) to ascertain if nutrition research shows signs of bias when funded by industry. This study found that industry funded scientific articles in this area were approximately 4 to 8 times more likely to be favourable to the financial interests of the sponsors than articles without industry related funding. None of the intervention studies with all industry support had an unfavourable conclusion. Lesser et al (2007) acknowledge that financial bias is not the only cause of bias; for example the a priori hypothesis indicates a preconceived notion of how an experiment will unfold.

[46] Includes Schulze et al (2004). Already discussed in text above.

[47] Includes Mrdjenovic et al (2003), Ludwig et al (2001) and DiMeglio et al (2000). Already mentioned in text.

[48] One of these included Ebbeling et al (2006) already mentioned in text.

With regard to soft drink consumption and milk and calcium intake, a negative association was identified – though not for all studies in the Vartanian et al (2007) review. For milk intake, significantly larger effect sizes were observed in longitudinal studies and in studies that included a variety of beverages, provided adjusted values, and in studies not funded by the food industry. For calcium intake[49] larger effect sizes were observed among adults and among studies that included a variety of beverages, while studies not funded by the food industry exhibited small negative effects. In considering soft drink consumption and nutrient intake, studies principally showed positive associations between consumption and added sugars, and reduced intake of fibre, protein, starch, riboflavin, fruit and fruit juice. Overall there was no association between soft drink consumption and fat intake or with intake of vitamins (e.g. A and B12). Interpreting these associations is complex as soft drink intake could be an indicator of overall poor nutrition, they could also stimulate the appetite for non-nutritious food. The authors were most surprised by the evidence linking soft drink consumption and type 2 diabetes; while links with metabolic disorders, hypocalcemia, bone mineral density, urinary or kidney stones, blood pressure and dental caries also featured.

Vartanian et al (2007), in their meta-analysis, considered an effect size of 0.1 or less as small, an effect size of 0.25 as medium and an effect size of 0.4 or above as large. The overall effect size across all studies for the relation between soft drink consumption and energy intake was 0.16. However, the more methodologically robust studies within this group had stronger effect sizes. The 12 cross-sectional studies effect size was 0.13; for the 5 longitudinal studies this was 0.24; while the long term experimental studies and the short term experimental studies also had stronger effect sizes - 0.3 and 0.21 respectively. For soft drink consumption and body weight, larger effect sizes were observed in experimental studies than in cross-sectional or longitudinal studies.

The authors (Vartanian et al, 2007) conclude that the data provided clear links between soft drinks and increased energy intake which were stark given this is just one source of

[49] One of the studies reviewed considering soft drink consumption and calcium intake (positive association) has already been mentioned in the text; McGartland et al (2003).

energy in the diet, and noted that there were few parallel nutritional advantages to consumption of these drink forms.

A systematic review by Gibson (2008)[50] included 44 studies[51] and outlined some of the difficulties with methodological rigour in these types of studies. Cross-sectional studies are prone to confounding and reverse causality. Longitudinal studies are also prone to confounding from concurrent changes in other aspects of diet and lifestyle and can contain attrition bias. While intervention studies have difficulties with ensuring comparability at baseline, compliance in the intervention group, non-contamination of the control group and adequate monitoring of diet and lifestyle during the trial period. Gibson (2008) also highlights publication bias – studies that do not demonstrate sizable impacts may not be published, and therefore this author disagrees with Vartanian et al (2007) statement of industry-funded studies' bias.

In this Gibson et al (2008) consideration of cross-sectional studies, 12 out of 27 studies had a statistically significant positive association between SSDs and BMI/overweight in at least one group. Of these, 2 use what Gibson (2008:135) describes as the 'gold standard' – 7 day weighted dietary records. One study found a positive association between BMI and consumption of high energy beverages, while the other found a positive association between high SSD (mean 870kj/d) and overweight (but there were other sources of energy showing stronger associations). Eight of the 17 longitudinal studies showed a significant positive association between SSD consumption and weight or weight gain in at least 1 subgroup. Within these 8, 4 showed results which were non-significant in another subgroup or lost significance on multivariate adjustment for confounders. Of the 2 intervention studies[52] reviewed by Gibson et al (2008) that are relevant to this review both were with children under age 18 and weight loss could be hypothesised to be linked to baseline weight; in other words that children who lost weight to a significant level may be more susceptible to weight gain.

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[50] This review was funded by a European beverage association union. The author declared independence.
[51] To include the following studies already discussed: Ebbeling et al (2006), Ludwig et al (2001), Mrdjenovic et al (2003), Schulze et al (2004) and James et al (2004) – the follow up study is discussed in the already mentioned James et al (2007).
[52] One being Ebbeling et al (2006).

This review concluded that avoiding SSDs could help prevent further weight gain in overweight people but further evidence is needed to prove that any impact is experienced by people with healthy BMIs, while there is little evidence that SSD are more obesogenic than any other source of energy.

Woodward-Lopez et al (2011) undertook a systematic literature review[53] to determine if sweetened beverage intake increases the risk for obesity and the extent to which it has contributed to recent increases in energy intake and adiposity in the US.[54] Five categories of evidence were considered; trends, mechanisms, observational, interventions, meta-analyses. Woodward-Lopez et al (2011) concluded that while more research was required (in particular RCTs) the evidence is extensive and in general supports SSD consumption as a risk factor for obesity – and it has made a contribution to the obesity rates recently experienced in the US. However, causality is difficult to establish in the latter case. Woodward-Lopez et al (2011) state that SSD consumption is a promising area of obesity prevention focus due to; their lack of nutritional benefit (other than energy and water), and that the evidence supporting this association is stronger for SSDs than any other single type of food or beverage. Although educational efforts may well be an important element of any strategy to reduce intake, the increases in obesity in recent decades are most likely the result of environmental and policy influences. Possibly acknowledging the complexity of the obesity issue, Woodward-Lopez et al (2011) state that increased portion sizes, low prices and increased availability and marketing have most likely contributed to the increased consumption of SSDs, and efforts to reduce SSD consumption should focus on these factors.

Sievenpiper et al (2012)[55] undertook a systematic review and meta-analysis of the effect of fructose on body weight in controlled feeding trials. Controlled feeding trial lasting a week or more that compared the effect on body weight of free fructose and non-fructose carbohydrate in diets providing similar calories (31 trials) or of diets supplemented with

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[53] PubMed database, January 1970-March 2010, English language.
[54] To include Vartanian et al (2007), DiMeglio et al (2000), Tam et al (2006), Vanselow et al (2009), Schulze et al (2004), Ebbeling et al (2006), Forshee et al (2008), Malik et al (2006).
[55] These authors declared a long list of potential conflicts of interest in a very transparent manner, to include makers of SSDs. This study was not industry funded and authors declare their independence.

free fructose to provide excess energy and usual or control diets (10 trials) were included. The former (31 trials) did not provide consistent evidence of a body weight increase effect of fructose whereas the latter (10 trials) did. Of interest to a European audience in particular, trials evaluating high-fructose corn syrup were excluded. In total, 41 trials were included; they tended to include small numbers of participants, were short in duration and of low quality. This study concluded that fructose does not appear to cause weight gain above and beyond what would occur when energy intake exceeds expenditure. Forshee et al (2008)[56] undertook a meta-analysis[57] of sugar sweetened beverages and BMI in children and adolescents to ascertain if SSD consumption is associated with increased BMI among young people and, if so, the magnitude of that effect. Eight longitudinal studies and two RCTs were incorporated into the meta-analysis which concluded that the association between SSDs and BMI was near zero. These authors disagree with Malik et al (2006) by considering later reviews and their own meta-analysis concluding that Malik et al (2006) did not consider magnitude or links between SSDs and obesity other than that may be associated with energy content.[58] Forshee et al (2008) stated that to the best of their knowledge, none of the included 12 studies were funded by industry. Forshee et al (2008) are criticised by Malik et al (2009) for analytic errors in their meta-analysis which Forshee et al (2009) counter while also noting that they did make errors, however rectifying these makes no difference to outcome. Malik et al (2009) in their reanalysis of the Forshee et al (2008) meta-analysis instead conclude that results suggest a positive association between SSD intake and children's BMI. The meta-analysis by Forshee et al (2008) is also criticised by Mattes et al (2010:360) for inconsistent arguments regarding validity of methods, concluding that some might argue that the burden of proof of the validity of measurements lies more heavily with those reporting no effect, because large random error will often (though not always)[59] obscure associations and account for the lack of effect.

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[56] This study was supported by a grant from the American Beverage Association. The research centre which the authors are affiliated with has received funding from 2 of the major beverage labels and the third author accepted a post with the American Beverage Association after her involvement with the manuscript. Authors declare their independence.

[57] To include the following studies already discussed: Ludwig et al (2001), Mrdjenovic et al (2003).

[58] This disagreement is discussed in Woodward-Lopez et al (2010:504).

[59] Authors' reference: Brenner, H. Loomis, D. (1994). 'Varied forms of bias due to nondifferential error in measuring exposure'. *Epidemiology* 5:510-17.

Mattes et al (2010)[60] undertook a systematic review and meta-analysis of RCTs to consider nutritively sweetened beverage[61] consumption and body weight. The strengths of this work include authors seeking out of unpublished research (overcoming publication bias), focussing only on experimental literature (addressing causation rather than association), and their partitioning of the literature into distinct categories that differed in terms of fundamental questions asked. The tight criteria led to 12 studies being considered eligible, while 10 of these were included in quantitative analysis and synthesis.[62] Mattes et al (2010:347) are particularly aware of the problems associated with evidence-based research in this area generally; there are considerable differences in study outcomes so we are faced with imperfect knowledge. Differences occur with regard to professional judgement, search strategies and population subgroups even when similar research questions/methods are posed. With regard to their meta-analysis, Mattes et al (2010) note that previous work has considered studies with fundamentally different questions which act against the attempts to overcome heterogeneity that are a feature of meta-analyses.

Mattes et al (2010) state that their meta-analysis shows that the available evidence on nutritively sweetened beverage consumption reduction programmes is suggestive but does not confirm that such programmes are effective, particularly for people who are overweight/obese at baseline. While Mattes et al (2010) believe the experimental evidence requiring participants to consume additional energy (in the form of these drinks) increases weight, is strong, the reverse of this is suggestive rather than gaining RCT supportive evidence. Therefore, there is not strong evidence that reducing consumption of nutritively sweetened beverages reduces BMI; however effectiveness trials reviewed did demonstrate that programmes to discourage consumption may have had modest beneficial effects on BMI change among people in the top third of BMI distribution. Mattes et al (2010:363) believe that RCT research is required to confirm/dispute these relevant research questions and continued observational work offers more heat than light while policymakers are required to act to address the problem of overweight/obesity and decisions must now be made based on imperfect knowledge.

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[60] Authors have received industry funding, however this study was not directly funded by industry.
[61] Authors use this term rather than SSDs or SSBs to focus on the property of delivering energy rather than the energy source.
[62] To include DiMeglio et al (2000), Ebbeling et al (2006), James et al (2007).

Already mentioned by several cited studies - Andreyeva et al (2010) undertook a systematic review of research on the price elasticity of food demand. All published US studies of food price elasticity of demand were identified and criteria applied for inclusion; 160 studies were reviewed. Soft drinks were found to be among the most responsive product to price changes; assuming no substitution with other calorific beverages and no changes in other factors affecting purchasing behaviour, the price elasticity of soft drinks suggest that a 10% tax could lead to an 8-10% consumption reduction as already outlined. The overall concern with regard to price sensitivity is that given the current economic climate that people will purchase low cost food which are frequently processed and energy dense. Andreyeva et al (2010) suggest that regressive taxation be off-set by price incentives for fruit and vegetables as well as public education. The authors conclude that studies estimating substitution effects from unhealthy to healthy food and price responsiveness among at-risk populations are particularly needed.

Throw et al (2010) undertook a systematic review on the effect of fiscal policy on diet, obesity and chronic disease, with 24 studies meeting the inclusion criteria. Eight of these studies were empirical and 16 were modelling studies. Soft drink taxes were the most common studies found with 10 such studies included in the review. Nine of these 10 studies have not been outlined already in the text above; and all but one of these was based on US data, with one from Norway. Five of these were empirical rather than modelling studies. The one study that has already been outlined in the text above and included in the Throw et al (2010) review is the Bahl et al (2003) empirical study from Ireland.

Among the 5 empirical studies of SSD taxation, 2 noted that expenditure did change with taxation, however the remaining 3 considered the impacts of a SSD tax on obesity and none identified any impact. One study did notice that in US states with a junk food or SSD tax that relative increases in obesity prevalence were lower than in states with no such tax or a repealed tax. SSD taxes in US states are generally low.

Throw et al (2010) concluded that, in general, taxation and subsidies influenced consumption in the desired direction with larger taxes being associated with more

significant changes in consumption, body weight and disease incidence. However, the authors felt that studies that focussed on a single target for taxation overestimated the tax impact by not taking into account the shift to other products. It was felt that the quality of the evidence was generally low.

Faulkner et al (2011) undertook a project with the aim of synthesising evidence regarding the impact of economic policies targeting obesity and its causal behaviours (diet, physical activity) to make recommendations for the Canadian context. A two-phase scoping review took place to include a literature review and expert consultation through a Delphi survey[63] and an in-person expert panel meeting. Although overall economic instruments were deemed to have a relatively modest impact on obesity, instruments targeting consumption were rated higher than those targeting physical activity. Of the instruments, changes to agricultural subsidies were deemed as having the greatest potential impact on obesity but the lowest feasibility, while food and beverage taxes/subsidies were similarly rated. SSD taxes were seen as having a small but, over time, powerful and synergistic effect with other measures. Three-quarters of the panel recommended a caloric sweetened beverage tax. This tax would be justifiable for three reasons; these drinks have no nutritional value, there was no indication from empirical evidence that such a tax would be regressive, and finally, the evidence is incomplete, particularly with regard to the assumptions underpinning the data, but tobacco control policies were also introduced without a strong evidence base. The impact will not be clear until such policies take effect. Higher taxes were recommended as well as ensuring that the taxes are calculated on a unit basis rather than price percentage to avoid quantity discounts. Ringfencing the revenue for obesity prevention initiatives as well as broadening the rationale beyond obesity to other health benefits were also suggested – the latter as a specific recommendation for the Canadian case. Three panel members felt there would be no impact on obesity due to substitution. An alternative plan was proposed; to tax

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[63] Delphi methods are an accepted methodological tool. For further information see Hasson et al (2000) http://onlinelibrary.wiley.com/doi/10.1046/j.1365-2648.2000.t01-1-01567.x/abstract;jsessionid=A58674B8A8600DF57A856A71A38B6A61.d04t04?deniedAccessCustomisedMessage=&userIsAuthenticated=true
And also Hanafin, S. Brooks, A.M. (Department of Children and Youth Affairs, June 2005) http://www.dcya.gov.ie/documents/research/TheDelphiTechnique.pdf [Accessed 21 September 2012].

sugar input which would impact industry rather than the consumer and therefore lead to reformulations. The specific recommendations for Canada were to; apply the tax on the amount of sweetener, to combine the tax with a subsidy/other obesity interventions, monitor unintended consequences of the tax in terms of the producers' formulations responses.

4.9 A Brief Note on Potential Economic Impacts

The loss of jobs and damage to the Irish economy is relevant to the HIA due to the links between ill-health, poverty and unemployment. However, figures related to economic impacts specific to SSDs (disaggregated from artificially sweetened beverages, other beverages, and alcoholic beverages) makes estimations on employment (direct and indirect), revenues and cross border shopping difficult to assess. As already outlined, unknown consumer responses compounds difficulty. Much as a robust evidence base for direct health impacts is required, so are precise and transparent figures for the economic impacts.

Food and Drink Industry Ireland (FDII) (IBEC, 2012) estimate their sector's potential jobs dividend up to 2020 to be 30,000 jobs across the entire economy (direct, indirect, induced). This industry is the largest manufacturing sector in Ireland providing high quality jobs, with exports of almost €9 billion in 2011, with a target of €12 billion by 2020. There are currently 43,111 people working in the food and beverage industry. FDII recommend that government and the food industry work together in a multi-stakeholder evidence-based platform of cooperation to reduce obesity levels, to protect reputation, competitiveness and employment and they claim that advertising restrictions and discriminatory taxes are ineffective policies.

There are few parallels between tobacco taxation and the proposed SSDs tax.[64] However given the longevity and experience with tobacco taxation, some research will be briefly considered as parallels can be made between the debates around both tobacco and SSD taxation (Chaloupka et al, 2011). Impacts on the economy and jobs are frequently cited;

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[64] In an invited commentary, Winkler (2012) notes the parallel made between SSD and tobacco taxation must be set in context; tobacco taxes in the UK add 348% to the retail price – it would not be possible to do this with a food item.

further inhibiting consumer spending, direct and indirect redundancies, cross border trade (albeit smuggling is not likely to be an issue, as it is with tobacco).

The tobacco industry argues that taxation and its intended impact to curb smoking will lead to a loss of jobs. However, this argument rests on the assumption that the money will disappear, rather than be spent in other sectors of the economy. Similarly, it could be argued that if consumers cut down on SSDs they will switch to other beverages such as artificially sweetened beverages or water. Producers of SSDs with a diversified product line may experience no dip in profits.

Ongoing research looking at the employment of SSB taxes that accounts for the job gains in other sectors due to changes in consumer and government spending, as well as the substitution to other untaxed beverages produced and bottled by the same companies, is likely to produce findings similar to those that demonstrate that higher tobacco taxes do not result in significant job losses and could even lead to a net increase in jobs. (Chaloupka et al, 2011).

Warner et al (1996) attempted to determine if declines in tobacco product sales would significantly reduce employment in the US. The researchers did this on the same terms as the tobacco industry – they did not include healthcare employment. Using two scenarios; no spending on tobacco, and reduced spending on tobacco, researchers used employment data and projections (1993-2000) and included scenarios taking into account government expenditure responses to changes in revenue. In the less likely scenario of no tobacco spend, in 1993 the Southeast US tobacco region would have had 303,000 fewer jobs, but the 8 non tobacco regions would have gained enough jobs to offset these losses. By the year 2000, with no spending on tobacco, 222,000 jobs in the Southeast US tobacco region would be lost but there would be a gain of 355,000 throughout the rest of the country. In the more likely scenario of a reduced spend on tobacco (double the downward trend), researchers estimated that in 1993 the Southeast tobacco region would lose 6,300 jobs (0.03% of regional employment) and 36,600 jobs by 2000 (0.2%). The 8 non tobacco regions would gain 6,400 jobs in 1993 and 56,300 jobs in 2000. The difference between these results and those presented by the tobacco industry

lies in the industry studies evaluation of gross impact only, while this study evaluated both gross and net impacts of tobacco on employment. The net impact includes redistribution of the former tobacco expenditures to other consumption. The employment sector most likely to be badly hit by tobacco taxation in the long term will be in the healthcare sector due to a healthier population, however more jobs may become available in geriatric care due to increased longevity of the non-smoking population (Warner et al, 1996).

Warner (2000) outlines the arguments that have been perpetuated by both the tobacco industry and the tobacco control industry, many of which are the same arguments used for and against a SSD tax. Not all of those outlined are relevant (e.g. smuggling), however the relevant arguments will be discussed here. The first is that tobacco cultivation, manufacture, distribution and sale will damage a country's economy through job loss, lost income, tax revenues. In response to this, Warner (2000) reiterates the point outlined above – that the money will be spent elsewhere in the economy – as well as noting that taxation is unlikely to produce an overnight effect while revenues are likely to be raised before they fall in response to consumer behavioural changes, and in fact if taxation continues to rise revenues may not dramatically plummet. Warner (2000) refutes the tobacco control lobby statements regarding the costs of tobacco-related healthcare and social costs. These health costs are principally borne by the individual (in private health insurance) while death at a younger age means that non-smokers are a greater burden on a public pension scheme than smokers. There are caveats associated with this in an Irish context (for example; public health care, costs of tobacco-related disability and productivity costs) but Warner (2000) is attempting to acknowledge the complexity of the issue while also dissuading public health from appealing to economic costs. Arguments against tobacco should be made on the basis of population health, not economics and doing otherwise is allowing the tobacco industry to shift the debate to fiscal rather than health policy. Warner (2000) also raises an issue familiar to the SSDs tax debate – the regressive nature of tax, hitting the poorest hardest, may actually qualify the tax as progressive with regard to the intensity of health impacts across the social gradient.

This is not a comprehensive overview of the impacts on employment, in particular the parallels between tobacco and SSDs are limited; rather this is an attempt to acknowledge that the policy proposal should be informed by transparent, independent economic data given the context within which the tobacco industry argues against taxation parallel many of the arguments against a SSD tax. Kamerow (2010) argues that experiences with tobacco control demonstrates that education is not enough; taxes, regulation and litigation are also needed while Klonoff (2009:410), who also cites the effectiveness of tobacco taxation, believes that epidemiologic and experimental evidence indicates that a greater intake of SSDs is associated with weight gain and obesity and that a SSD tax is sound public policy.

4.10 Final considerations

Research in all fields, not just SSDs, has limitations. In this case, limitations include self-reported data, attrition, compliance, children at different growth rates, sample sizes, the necessity to comply with research ethics, to name but a few. This review mirrors much of the discussion in the literature cited in not being able to provide clear answers and, from a policy point of view, decisions may need to be taken in the absence of complete knowledge, as action is needed to address the growing problem of obesity; absence of evidence is not evidence of absence. One strand of evidence can be stated with relative confidence; excess sugar in the diet can cause weight gain.

There are other health issues that could be positively impacted by dietary sugar reduction such as dental health. Many of the health problems associated with obesity, such as metabolic syndrome and type 2 diabetes, were shown in some research to have an independent relationship with SSDs while controlling for obesity. The most consistent evidence does show that SSDs provide energy that, if not compensated for by reducing/expending energy in other ways, can cause weight gain. But do SSDs do this above and beyond other consumed food/drink? Therefore, is it fair to target this one source of energy? Many reviewed studies advocate for SSD taxation as it is considered a good place to start. It is one energy source that provides no other nutritional benefits, and may cause dietary displacement of other more healthful drinks. This may not be an issue among people who rarely consume a SSD, but may be a problem for people who are

frequent consumers. These latter consumers may be the target group for such a tax, but it is unknown if they will simply pay more or switch to a similar (or cheaper) product. The greatest unknown is around consumer substitution; what will consumers switch to if they are not drinking SSDs? There may be implications across the board with market reforms at EU level (see Bonnet et al, 2011).

With regard to taxation effecting positive behavioural change, the research is also not conclusive. Basic economics informs that if price goes up, consumption will go down. But again, the great unknown is what will consumers switch to, assuming the proposed tax would be passed on to the consumer at least in part by industry? In addition, there is the question of social justice; would such a tax be regressive? Reflecting the fact that SSDs consumption is common among low income households, a tax would have a disproportionate burden on these lower income households. However, if there were health benefits to the tax, these health benefits would also disproportionately fall on low income households. From a health benefits perspective, such a tax could be considered progressive.

Warner (2000) outlined, that as with tobacco taxation, SSD taxes are regressive in impacting low income households to a greater extent, however, as with tobacco taxation, it may be among the low income households that behavioural change is targeted. This may actually qualify the tax as progressive with regard to the intensity of health impacts across the social gradient. However, overall if positive behaviour change is not an outcome, it could mean that the low income food basket will absorb more of the household budget, or that other items, possibly healthier options, could be dropped in favour of SSD purchase and keeping within the typical weekly budget. Similar to tobacco, SSDs are not an essential product. There are free alternatives such as water. However consumption of SSDs may be a proxy for a generally unhealthy lifestyle which may make targeting them unfair; however by taxing them there is also an opportunity to raise awareness, generate innovative reformulation and perhaps provide an opportunity to create dents in the armour of obesity.

As can be seen from Faulkner et al (2011) as discussed above, introducing SSD taxes as part of a series of interventions is a reoccurring theme across the literature, particularly to counteract substitution effects. In addition, revenue hypothecating for health promotion is frequently cited, while the methods of implementing the tax are often discussed in terms of being cognisant of how the market might respond – for example counteracting price rises through discount volume sales.[65] Mytton et al (2012) argue that taxing a wide range of unhealthy foods/nutrients is likely to result in greater health benefits than would accrue from narrow taxes, but the strongest evidence base is for a tax on SSDs, however this tax needs to be at least 20% to have a significant effect on obesity and cardiovascular disease. In addition, Mytton et al (2012) echo a sentiment throughout the literature that taxes on unhealthy food should ideally be supported with subsidies on healthy foods such as fruit and vegetables. This would also assist in making these forms of taxation more palatable – although hypothecating of revenue generated by a tax is not recommended in pure economics terms it may be necessary to ensure it is not seen as yet another method of revenue generation.

[65] See in particular the 'Point/Counterpoint' piece (Chaloupka et al and Fletcher et al in Couch (ed.), 2011).

5. Stakeholder Consultation

An important component of a HIA is to consult with stakeholders and a stakeholder event was organised for 12th June 2012 in the Department of Health. The purpose of the stakeholder meeting was:

- To inform stakeholders of the process to date.
- To provide an opportunity for stakeholders to share their knowledge and opinions on potential health impacts of the proposal, both positive and negative.
- To provide an opportunity for stakeholders to make recommendations on how the proposal could be enhanced for better health.

The intention was to invite stakeholders from as wide a spectrum of interest as possible to include; business and industry groups, representatives from health organisations and agencies, consumers, young people and representatives of youth and children organisations, representatives of disadvantaged groups, representatives from academia and the food sector. In total, 92 people were invited, 56 responded and 50 people attended on the day. Over two weeks notice was given, and a reminder email was circulated.

Event Overview

The event was chaired by Professor Donal O'Shea, consultant endocrinologist, who principally deals with the treatment side of obesity.

Minister Reilly opened the event by expressing his concern that with regard to obesity and associated diseases such as diabetes, we may be burying the generation behind us. Minister Reilly stated that the intention of the proposal was not to harm industry but to be a step in the right direction and one of a number of measures being considered to address the obesity problem. Minister Reilly welcomed the industry presence and advocated for innovation where the right consumption choice would become the easy

choice. He stated that we need to stop talking about prevention and start doing it; in this, all of Europe is moving in the same direction.

Paul Kelly, Director of the Food and Drink Industry in Ireland (IBEC) spoke, noting that 1 in 8 jobs in Ireland is in the agri-food sector, with 600 food companies operating in Ireland. This industry is one of few large scale industries in Ireland where the entire supply chain is held within our borders. Mr Kelly stated that 2,500 people work in the soft drink industry. By 2020 the aim is to grow agrifood exports to the advantage of 30,000 jobs. Any new measures should be evidence-based and transparent. Mr Kelly wished for clarification on the HIA process.

Mr Kelly pointed that there is already a high rate of VAT on SSDs in Ireland and wished to point out some international examples. France introduced a soda tax in January 2012; the new duty will equate to 7.16c per litre. Portugal has increased its SSDs tax to 23% in the last number of months. Irish data shows that the contribution of beverages to children's energy is 7%, and for teenagers this is 6%. This proposed tax would be blunt and regressive on a population level basis, impacting on already strained household budgets and could drive consumers across the border while further depressing consumer sentiment. Reformulation is a possibility, and much has already been done in this area – for example industry work towards salt reduction. Information and education of consumers, and physical activity is essential.

Professor O'Shea stated that from his perspective the situation is critical and prevention methods are essential. He stated that Ireland can be an exemplar as an island and we should be willing to make mistakes before we get it right.

An overview of the HIA process was provided by IPH and stakeholders were divided into 4 smaller groups for discussion of the issue, with a facilitator and scribe present to guide and record discussions.

Questions to guide facilitated discussions:

- What are your concerns about the proposal?
- What effect do you think the tax will have on consumption of SSDs?
- In general, price increases affect high consumers and those with limited income more than the general population. Is this likely here? If so do the potential health benefits justify the measure?
- What do you think will be the proposal's positive impacts on health and well-being?

  How do you think we can enhance or increase any positive impacts?
- What do you think will be the proposal's negative impacts on health and well being? How do you think we can avoid or minimise any negative impacts?
- What additional and/or alternative measures could be introduced to support the objective of tackling obesity and improving health?

The full stakeholder group was reconvened for feedback provided by each group and Professor O'Shea thanked attendees and closed the event.

The recorded notes from the workshop scribes were analysed by IPH and the key points ensuing in discussion are summarised in thematic areas below.

Issue 1 – Employment/industry impacts

- The tax may impact on sales and effect industry and therefore jobs, while only having a nominal impact on obesity.
- The tax could lead to reformulation and innovation.
- Marketing responses: will industry think of ways to maintain consumption levels?; for example, absorbing the tax and placing it elsewhere in the product line? Minimum pricing may be a better option, or perhaps a tax based on sugar content.
- Use salt reduction as a good example of how working with industry is beneficial and has been successful.

Issue 2 – How the tax is implemented

- Concern about how the tax will be implemented: based on price/sugar content?; retailers can decide own prices; will it impact on restaurants as well as retailers?; industry versus consumer bearing the brunt?; tax may need to be between 10-20%; regulatory burden of implementation?
- How will it be monitored for success?
- Ring-fenced for health promotion? There was opposition to this as hypothecation is not considered a good policy decision from an economics point of view, but others thought ring-fencing for health promotion initiatives was a good idea.
- Suggestion to provide an annual report on success and interventions paid for through ring-fenced money.
- Cannot be seen as another revenue raiser (money grab)
- Will it alter consumption patterns for the better or worse?

Issue 3 – Methodology and evidence

- Some stakeholders thought that there was enough evidence clearly available to introduce the tax, while others thought there was not. Others thought that a lack of evidence was an excuse to hide behind and there is a real need to start doing something. Others thought it was a cynical political move to be seen to be doing something.
- Do we need to wait for Irish evidence – we do not for clinical trials?
- Why focus on this one form of energy intake?
- Will it really make any difference to obesity as obesity is multifactorial?
- Sugar/fat see-saw; will it change consumption patterns for 'as bad' or 'worse' substitution products?
- Is this too small a tax percentage to make any significant difference?
- One stakeholder stated that the consumption of low calorie drinks has gone up, the consumption of SSDs has gone down – but there has been no change in obesity.
- Not just about obesity – dental health, cardiovascular disease and other non communicable diseases, even diet versions of carbonated drinks affect teeth.

Issue 4 – Potential inequalities

- Impact anticipated to be primarily on the poor and youth.
- It may impact on people who are currently obese or consuming too much – but in a meaningful way? It might not make any significant impact on obesity and young people may not yet be obese due to physical activity.
- Education is needed, not (just a) tax.
- Possibility of subsidising healthier products? But fruit and vegetables are already cheap.
- Poverty Impact Assessment is also needed.
- Impact on poorer families' food basket – other foods might be dropped not the SSDs.

Issue 5 – Alternative/additional suggestions

- A full package of interventions is necessary. Need to look at variety of food categories for taxation, as well as physical activity.
- Education is essential – across the board; children, parents, workplaces etc.
- Consider portion size.
- Consider salt intake – increases thirst.
- Consider addressing advertising and marketing of these products.
- Subsidies – though retailers may come up with their own methods.
- The trade unions and employer organisations should be involved in measures in address obesity.
- Calorie posting and food labelling need to be addressed.
- Promote existing and develop community food initiatives.
- This is demonising one food while others are falsely 'angelicised' (e.g. so called superfoods).
- How will it address multipacks and promotions?
- Taxing will be its own education – make people aware.
- Why are people drinking SSDs? It is not because of cost but because of temptation. Need to educate to address temptation, locus of self control similar to tobacco. The structures exist in schools (e.g. SPHE) to do this.
- Consider restrictions on availability, like with tobacco; packaging, vending

machines.

- Economic impacts of associated health problems should be considered.

Issue 6 – Consumer response

- People may move to other drinks with sweeteners that are not healthy either.
- What will they buy instead – something unhealthier?
- Satiety – empty calories, people do not reduce food intake.
- Adults and children using sports clubs may switch to energy drinks that they do not need.
- Can't have people thinking that to stay away from SSDs is the only answer.
- May start a dialogue about healthier choices.
- Will it encourage cross-border shopping?

6. Parallel Information

In parallel to the HIA, the Department of Health undertook 2 supplementary pieces of research. A team in the University of Oxford undertook an exercise to model the effects of a 10% SSDs tax in Ireland on obesity and overweight. This work and key findings are outlined below and the full report is available in appendix 9. In addition, the Department of Health obtained polling information on opinions and attitudes towards SSDs. This information is available in appendix 9.

6.1 Summary: Modelling Exercise

In parallel to the HIA process, Dr. Mike Rayner and his team in the University of Oxford were invited by the Department of Health to model the effects of a 10% tax on SSDs in Ireland on obesity and overweight, and to describe the effects by age, income group and consumption (regular versus low consumers). The full report, including limitations associated with modelling exercises of this nature, is available in appendix 9 and key headline results are outlined below:

- A 10% tax on the price of SSDs is predicted to reduce the number of obese adults (BMI≥30kg/m^2) by approximately 10,000 (95% credible intervals: 7,000-13,000) and the number of adults who are overweight, including obese, (BMI≥25kg/m^2) by 14,000 (10,000-18,000). This represents a reduction in obesity of 1.25% and in overweight, including obese, of 0.67%. Of the estimated 10,000 fewer obese adults, approximately 80% are regular SSD consumers.
- The impacts on men and women are similar (predicted reduction of 5,300 fewer obese women and 4,600 fewer obese men).
- The average reduction in energy intake in the adult population of Ireland as a result of a 10% tax is predicted to be 2.1kcal per week; the predicted reduction is greater among younger people and in regular SSD consumers.
- While obesity shows a gradient across income groups, this is slight. The impact of the tax on obesity across income groups is expected to be broadly similar. Different price responses by different economic groups are not modelled.

7. Conclusion

This section summarises the key information presented to the HIA steering group for consideration in making their conclusions and remarks to the SAGO group. In this it considers; the population profile, stakeholder consultation and literature review, while also taking into account the modelling work and noting the polling information that paralleled the HIA process.

In 2010, Ireland consumed 83 litres of carbonated beverages[66] per capita, and SSD consumption is currently higher among certain population subgroups than others. For example 37% of 18-64 year olds consume carbonated drinks compared to 9% of those aged 65 and older. Among young people in Ireland aged 5-18 years, 75% and over in each age cohort consume carbonated beverages. In general, males across all age categories are more likely to consume carbonated beverages, and consumption is more prevalent among lower socio-economic groups. Polling information demonstrated that respondents believe that children and young people drink too many SSDs.

Obesity is multifactorial; it is not caused by one facet of an individual's lifestyle, but instead can be caused by environmental, physiological, genetic and lifestyle factors. This complex mix of factors means that solutions to the problem of overweight and obesity are not simple but the food environment will certainly form an integral part of addressing this issue. Some of this complexity is reflected in the stakeholder consultation where diverging views and uncertainty were apparent. Overweight and obesity in Ireland have reached concerning levels. In the National Adult Nutrition Survey (IUNA, 2012a), 37% of all adults were overweight and 24% were classified as obese. SLÁN (2007) results state that approximately 2 out of 3 Irish adults are either overweight or obese (Harrington et al, 2008). Adult males are more likely to be overweight/obese than females across all age cohorts. Results from IUNA (2012c) stated that overall, 15% of children between 2 and 4 years old were overweight and 3% were classified as obese. Among children aged between 5 and 12 years, 17.4% were overweight and 6.7% were classified as obese while

[66] See appendix 5 for definition of carbonated beverage; in sum, 'carbonates' refer to sweetened non-alcoholic drinks containing carbon dioxide and therefore include artificially sweetened drinks. For a detailed breakdown of SSD consumption by gender and age, please see table 3.8.

for teenagers (13-17 years) 15% were overweight and 3% were obese. The Growing up in Ireland study (2011) reported that 19% of children aged 3 were overweight, with a further 6% measuring as obese. A social gradient occurred for both adults and children with regard to weight – among adults this was not the case for overweight, but was the case for the prevalence of obesity.

The proposal for a tax on SSDs is rooted in concern over the problem of obesity in Irish society, and it is estimated that diseases associated with obesity will become increasingly common. Obesity can lead to serious health problems such as type 2 diabetes and metabolic disorder and although the causes of obesity are multifactorial, diet is one of the key influential factors. SSDs have come under considerable scrutiny for their possible contribution to overweight and obesity. SSDs are considered by some advocates as a good place to start in terms of food taxes as SSDs provide no nutritional benefits to the consumer. However others do not share the enthusiasm for a tax arguing that it is too simplistic a measure and not based on conclusive evidence.

What can be stated conclusively, as with any food/drink commodity, is that if energy intake exceeds energy expenditure there will be weight gain. Several mechanisms have been postulated to explain how consumption of SSD could lead to weight gain and obesity. The mechanism most often cited in the literature is one in which the 'liquid calories' of SSDs do not fully satiate appetite leading to additional consumption of calories in the diet. The evidence supporting this hypothesis is suggestive not conclusive. The question of satiety as unique to SSDs is mirrored by a possibly unique effect of SSDs on the body; for example, it is hypothesised but not proven that SSDs may contribute to diseases such as type 2 diabetes beyond the interaction with obesity through providing rapidly absorbable carbohydrates. The modelling exercise paralleling the HIA estimated that a 10% tax on the price of SSD, using an own-price elasticity of 0.9 for SSDs, would reduce obesity by 1.25% among adults in Ireland. The reduction in SSD consumption would occur to a slightly greater extent among women than among men but there would be no discernable differences between income groups. If this were the outcome, this would be a major public health achievement but the predictions must be viewed with caution. The modelling exercise has limitations, as with most exercises of this nature;

these, including assumptions that were made, are outlined in the University of Oxford report. It made an assumption that 90% of the tax would be passed on. It did not take account of switching behaviour i.e. what will the consumer replace the SSD with. It cannot be certain that the predicted weight loss is accurate for smaller energy reductions below the validated range of the equations used in the model. However, equating reduced energy intake from such a measure with weight loss is extremely challenging – especially as this initiative would not be occurring in isolation.

The balance of evidence for a link between SSD consumption and higher energy intake is in favour of a positive relationship. The balance of evidence concerning a link between SSD consumption and weight gain is less clear. Systematic reviews of published studies on SSD consumption and weight gain vary greatly in their findings even though they often review the same published studies. However, overall the evidence linking SSD consumption with weight gain is suggestive of a positive association rather than conclusive.

Meta-analysis of studies on SSD consumption and increased energy intake show consistent positive relationships with small to medium effects. Small positive relationships also seem to emerge for meta-analyses on studies of SSD consumption and measures of weight gain. However, it also has to be considered that the meta-analyses have been conducted on a suite of studies that have variously been criticised in the literature for being at the lower end of the quality scale or having design flaws. There are few studies in any research area that do not have limitations, Mattes et al (2010) note that we are faced with imperfect knowledge. Most research taking place outside of a controlled laboratory environment has limitations. Compounding this imperfect knowledge is the fact that this is not occurring in a vacuum, there are other policy interventions and wider economic factors that may play a part; for example the potential 36% decrease in sugar prices that may be forthcoming in Europe as outlined in Bonnet et al (2011).

Steering Group Conclusion

The steering group believe the evidence presented to them by the HIA process demonstrated that:

- Obesity is multifaceted with many factors influencing the basic drivers of energy intake and energy expenditure including environment, socio-economic, psychosocial and genetic factors.
- SSDs are a source of energy intake with little or no other nutrient contribution to the diet.
- Price increases tend to decrease demand but the degree to which this happens is variable because consumer behaviour and industry response to a tax is difficult to predict.
- The evidence linking SSD consumption with increases in energy intake is in favour of a positive relationship.
  The evidence linking SSD consumption with weight gain is suggestive but not conclusive. The literature is contradictory and study quality tends to be described as low to medium.

There are a number of uncertainties surrounding these agreed points that have been discussed earlier. Many of these uncertainties could be clarified by a comprehensive monitoring and evaluation process to ascertain consumption patterns, population BMI and industry impacts if the proposed tax was introduced. Causality and segmented data may be difficult to assess but the responsibility of planning for this monitoring and evaluation process lies with the Department of Health prior to introduction of the tax should it proceed. The HIA process was not asked to consider complementary measures and therefore cannot offer recommendations in this regard, however it should be noted that education and accompanying measures to promote physical activity were consistently raised by stakeholders as a necessary component of a suite of measures to address the issue. It should also be noted that the importance of engagement with industry prior to moving forward with a tax has also been consistently raised by stakeholders, with the example of industry collaboration in the area of salt reduction cited as a precedent.

Appendix 1: Steering Group Membership and Terms of Reference

Chair: Professor Donal O'Shea, St. Vincent's University Hospital, St. Colmcille's Hospital, and University College Dublin.

Members:
Ms. Ursula O'Dwyer, Department of Health
Dr. Pat Doorley, HSE
Dr. Teresa Bennett, HSE
Dr. Wayne Anderson, Food Safety Authority of Ireland
Dr. Cliodhna Foley-Nolan, Safefood
Ms. Marian Byrne, Department of Agriculture, Food and the Marine
Ms. Anne-Marie Brooks, Department of Children & Youth Affairs
Dr. Mike Rayner, British Heart Foundation Health Promotion Research Group and University of Oxford
Professor David Madden, School of Economics, University College Dublin
Mr. Owen Metcalfe, Institute of Public Health in Ireland (Project Team)
Dr. Noëlle Cotter, Institute of Public Health in Ireland (Project Team)
Ms. Teresa Lavin, replaced by Ms. Olga McDaid from July 2012, Institute of Public Health in Ireland (Project Team)

Objective

- To provide governance for the health impact assessment (HIA) of the proposal to place a tax on sugar sweetened drinks purchased in the Republic of Ireland.

Terms of reference

- To oversee the HIA and guide the project team as necessary.
- To hold meetings at regular intervals and to read and comment on any materials in advance.
- To approve each phase of project development; literature review, consultation process and draft documents.

- To ensure that the project is progressing at an appropriate pace given the short timescale.
- To provide support to the project team as required.

Appendix 2: Screening Tool

Introduction

Health is determined not only by access to quality healthcare services and lifestyle choices but also by the social and economic conditions in which people live. These include many factors which lie outside the healthcare sector, such as housing, employment, transport and access to fresh food. Policies and actions formulated in these non-healthcare sectors can have a significant impact on people's health and wellbeing.

Assessment of the potential impacts on health of a proposal should include consideration of physical, mental and social health. Health Impact Assessment (HIA) is a combination of procedures, methods and tools that systematically assesses the potential effects of a proposal on the health of a population. It also considers the distribution of those effects within the population and can be a useful mechanism for highlighting where the health of some groups may be affected more than others if the proposal is implemented.[67] The Institute of Public Health in Ireland (IPH) has developed tools to support HIA in practice.

Screening

Screening is the first step in a HIA and its purpose is to determine whether or not to proceed further with HIA. It does so by quickly and systematically highlighting the potential impacts of the proposal on health. Screening may be undertaken by a single person or as a group exercise. The length of time required for screening will depend on the scale of the proposal and the amount of information available. If screening is undertaken by a group, this should ideally include stakeholders (those likely to be affected by the proposal) and decision-makers.

The IPH screening tool comprises three sections:

- Section one records background and context.
- Section two considers the potential impact of the proposal on a range of

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[67]International Association for Impact Assessment. *Best practice guidelines for HIA 2005.* http://www.iaia.org.

health determinants, for the population as a whole and for groups within the population.

- Section three documents the outcome of screening.

Section one: Background and context

Title of proposal being screened	Proposed Sugar Sweetened Drinks (SSD) Tax
Date screening conducted	1st March 2012
Person(s) involved in the screening process (name, organisation represented and job title if applicable)	Noelle Cotter & Teresa Lavin Public Health Development Officers, IPH
What stage of development is the proposal at?	Very early stage, no documents available yet but the proposed tax is being explored by the Special Action Group on Obesity chaired by the Department of Health.
Briefly outline the importance of the proposal from: An economic/ business perspective A political perspective A community perspective	A change in SSD consumption may have implications for employment and revenue. The above issues have a political dimension as does the current level of obesity and related healthcare costs. Potential to affect all consumers of soft drinks.
What resources are available to conduct a HIA? (Consider both human and financial)	Two staff from the Institute of Public Health in Ireland on a part-time basis.
Are decision-makers likely to be open to recommendations to amend the proposal?	The HIA was requested by the Department of Health and therefore it is likely that the decision makers will be receptive.

Section two: Potential impacts on health determinants

Instructions for completing the table

The first column contains a list of issues that are known to influence health (health determinants). These are grouped into social and economic conditions, structural issues, and individual and family issues.

STEP 1: Assess the likelihood of the proposal impacting on this health determinant and record as:

- **Likely** (it is likely that the proposal will impact on this health determinant).
  Code as L
- **Unlikely** (it is unlikely that the proposal will impact on this health determinant).
  Code as U
- **Not known** (there is insufficient information in the proposal to assess whether or not it will impact on this health determinant).
  Code as NK

*If the health impact is considered **likely**, continue to step 2. If the health impact is considered **unlikely** or is **not known**, proceed to step 3 or move on to the next health determinant.*

STEP 2: List the groups most likely to be affected by the proposal. Examples of different population groups are given below (this is not intended to be a complete list).

- Infants and toddlers
- Children and young people
- Working age people
- Older people
- Rural population
- Urban population
- Males/ females
- Single/ married people
- Gay/ lesbian people
- People with dependants
- Racial and ethnic groups (particularly minority groups)
- People with particular religious beliefs
- People with particular political opinions
- People with disabilities
- Chronically ill people
- Homeless people
- Unemployed people
- Economically disadvantaged people
- Others

Social and economic conditions that influence health		
Likelihood that the proposal will impact on this health determinant (L/ U/ NK)		Groups most likely to be affected by the proposal
Education	U	
Employment	L	Those employed in the sector
Childcare	U	
Crime and fear of crime	U	
Community interaction	U	
Access to fresh food	U	
Access to sports and other opportunities for physical activity	U	
Access to cultural and other recreational activities	U	
Access to healthcare services	U	
Access to social welfare services	U	
Access to other community services	U	
Access to public transport	U	
Other social or economic conditions (list)		
Structural issues that influence health		
Likelihood that the proposal will impact on this health determinant (L/ U/ NK)		Groups most likely to be affected by the proposal
Housing	U	
Public buildings	U	
Commercial buildings	U	
Green space (including parks)	U	
Other public spaces	U	
Road safety	U	
Transport infrastructure	U	
Communications infrastructure (internet/telephone)	U	
Energy sources	U	
Waste management infrastructure	U	
Water quality	U	
Air quality (indoor and outdoor)	U	
Soil quality	U	
Noise	U	
Light	U	
Other structural issues (list)		
Individual and family issues that influence health		
Likelihood that the proposal will impact on this health determinant (L/ U/ NK)		Groups most likely to be affected by the proposal
Diet	L	All consumers of soft drinks especially frequent consumers
Physical activity	U	
Substance use (legal and illegal)	U	
Sexual activity	U	
Household income	L	Low income groups
Family cohesion	U	
Other individual and family issues (list)		

Section three: Screening outcome

Tick the appropriate outcome

Overall, health impacts are unlikely or relatively minor and easy to address.	Where appropriate, make recommendations to decision-makers on how such impacts may be addressed. Do not proceed with HIA.	
Overall, health impacts are likely or unknown.	Taking into account issues raised in section one, proceed with HIA.	✓

Appendix 3: Scoping Tool

Scoping tool[68]	
Title of the proposal on which the HIA is being conducted	Proposed tax on Sugar Sweetened Drinks (SSD)
Aim of the HIA	The proposed tax, to be applied to SSDs, may affect health and health inequalities. The HIA will assess potential impacts of the proposal in a systematic and transparent way.
Values underpinning the HIA	Equity Transparency
Objectives of the HIA (Consider core values)	Contribute to ensuring maximum health benefits are realised from the introduction of this policy and any potential health inequalities are minimised. Opportunity for broad stakeholder involvement and awareness of the rationale for introduction of the policy.
Boundaries of the HIA (e.g. geographical, population)	National Policy
Time scale for the HIA	Final recommendations and report to be presented to the Department of Health in September 2012
Non-negotiable aspects of the proposal	To be advised
Steering group membership Suggest maximum of 12 members Include decision-makers of the policy, programme or project on the group	See attached list
Main stakeholders: Who is likely to be affected by the proposal? Are key stakeholders represented on the steering group?	Consumer Soft drinks industry Health professionals – represented Food and agriculture sector –represented
Key informants for the HIA: Who can provide useful information on how the proposal is likely to impact on health?	Above groups
Who will be responsible for gathering evidence in the following areas? Literature review Community profile Stakeholder workshops Proposal and policy analysis	Project Team
Who will be responsible for appraising the evidence and forming recommendations?	Steering group and SAGO
How will the results of the HIA be presented and disseminated?	Results presented to the Department of Health Wider dissemination process to be advised
What measures will be put in place to facilitate evaluation of the HIA?	Impact / Outcome evaluation to be advised

[68] Adapted from a tool developed by Erica Ison.

How will the HIA budget be spent? Consider: Human resources Venue hire, catering and travel costs for meetings and workshops Costs associated with dissemination of the results Evaluation costs	In kind
Operating arrangements for the steering group including: Chair Date and location of meetings Secretariat	Meetings will be chaired by Professor Donal O'Shea and held in Hawkins House, approximately once a month for five months. IPH will act as secretariat.

Appendix 4: IPH prevalence estimates of selected chronic conditions

Number of cases and prevalence of clinical diagnosis of CHD (angina and heart attack)[69] (IPH, 2012a)

Year	Characteristics						
	Gender	Age group % (number of cases)					
		18+	18-44	45-54	55-64	65-74	75+
2010	Male	2.3% (36776)	0.3% (3053)	1.5% (4351)	4.3% (9759)	6.7% (9329)	11.6% (10284)
	Female	2.5% (42342)	0.3% (3128)	1.5% (4337)	4.3% (9699)	6.7% (9816)	11.6% (15362)
	Both	2.4% (79117)	0.3% (6181)	1.5% (8688)	4.3% (19458)	6.7% (19145)	11.6% (25646)
2015	Male	2.5% (42791)	0.3% (3019)	1.5% (4699)	4.3% (10624)	6.7% (11631)	11.6% (12818)
	Female	2.7% (47373)	0.3% (2916)	1.5% (4629)	4.3% (10599)	6.7% (11927)	11.6% (17302)
	Both	2.6% (90164)	0.3% (5935)	1.5% (9328)	4.3% (21223)	6.7% (23558)	11.6% (30120)
2020	Male	3.0% (49600)	0.3% (2911)	1.5% (5128)	4.3% (11724)	6.7% (13655)	11.6% (16183)
	Female	2.8% (53658)	0.3% (2798)	1.5% (4981)	4.3% (11772)	6.7% (14005)	11.6% (20102)
	Both	2.8% (103259)	0.3% (5708)	1.5% (10109)	4.3% (23496)	6.7% (27659)	11.6% (36286)

Population prevalence estimates of stroke (IPH, 2012b)

Year	Characteristics						
	Gender	Age group % (number of cases)					
		18+	18-44	45-54	55-64	65-74	75+
2010	Male	0.7% (10752)	0.2% (1457)	0.3% (909)	1.7 (3953)	1.4% (1973)	2.8% (2460)
	Female	0.7% (12078)	0.2% (1492)	0.3% (906)	1.7 (3929)	1.4% (2076)	2.8% (3675)
	Both	0.7% (22830)	0.2% (2949)	0.3% (1815)	1.7 (7882)	1.4% (4049)	2.8% (6135)
2015	Male	0.7% (12252)	0.2% (1440)	0.3% (982)	1.7% (4304)	1.4% (2460)	2.8% (3066)
	Female	0.7% (13313)	0.2% (1391)	0.3% (967)	1.7% (4294)	1.4% (2522)	2.8% (4139)
	Both	0.7% (25565)	0.2% (2831)	0.3% (1948)	1.7% (8597)	1.4% (4982)	2.8% (7206)

[69] Figures are based on self-reported, doctor-diagnosed angina or heart attack in the previous 12 months from SLÁN 2007. Future forecasts are based on the CSO's population projections (M0F1 Recent variant).

2020	Male	0.8% (13969)	0.2% (1389)	0.3% (1071)	1.7% (4750)	1.4% (2888)	2.8% (3872)
	Female	0.8% (14915)	0.2% (1335)	0.3% (1040)	1.7% (4769)	1.4% (2962)	2.8% (4809)
	Both	0.8% (28883)	0.2% (2723)	0.3% (2111)	1.7% (9518)	1.4% (5850)	2.8% (8681)

Population prevalence estimates of diabetes[70] (IPH, 2012c)

Year	Characteristics						
	Gender	Age group % (number of cases)					
		18-34	35-44	45-54	55-64	65-74	75+
2010	Male	0.5% (2570)	1.1% (3534)	4.9% (13882)	10.9% (24718)	11.4% (16037)	11.5% (10227)
	Female	0.5% (2682)	1.1% (3505)	4.9% (13838)	10.9% (24567)	11.4% (16873)	11.5% (15277)
	Both	0.5% (5252)	1.1% (7039)	4.9% (27719)	10.9% (49285)	11.4% (32910)	11.5% (25504)
2015	Male	0.5% (2380)	1.1% (3863)	4.9% (14993)	10.9% (26909)	11.4% (19995)	11.5% (12747)
	Female	0.5% (2295)	1.1% (3741)	4.9% (14769)	10.9% (26847)	11.4% (20503)	11.5% (17207)
	Both	0.5% (4675)	1.1% (7604)	4.9% (29762)	10.9% (53755)	11.4% (40497)	11.5% (29954)
2020	Male	0.5% (2174)	1.%1 (4004)	4.9% (16360)	10.9% (29696)	11.4% (23473)	11.5% (16094)
	Female	0.5% (2081)	1.1% (3868)	4.9% (15893)	10.9% (29818)	11.4% (24074)	11.5% (19992)
	Both	0.5% (4255)	1.1% (7872)	4.9% (32253)	10.9% (59513)	11.4% (47547)	11.5% (36086)

[70] Based on SLÁN 2007.Data for 18-44 year age groups are clinically diagnosed diabetes based on self-reported, doctor-diagnosed diabetes in the previous 12 months or reported taking diabetes medications in SLÁN 2007. No data were available on undiagnosed diabetes for 18-44 years.
Data for 45+ year age groups are clinically diagnosed diabetes based on self-reported, doctor-diagnosed diabetes in the previous 12 months or reported taking diabetes medication and undiagnosed diabetes (no clinical diagnosis in the previous 12 months and not taking diabetes medication but physically measured as diabetic (HbA1c>=6.5%).

Population prevalence estimates of hypertension (IPH, 2012d)

Year	Characteristics						
	Gender	Age group % (number of cases)					
		18-34	35-44	45-54	55-64	65-74	75+
2010	Male	2.5% (14022)	5.8% (19403)	49.0% (138806)	65.1% (147730)	71.3% (100010)	78.2% (69515)
	Female	2.5% (14633)	5.8% (19246)	49.0% (138370)	65.1% (146825)	71.3% (105224)	78.2 (103845)
	Both	2.5% (28656)	5.8% (38650)	49.0% (277173)	65.1% (294552)	71.3% (205232)	78.2 (173359)
2015	Male	2.5% (12988)	5.8% (21211)	49.0% (149923)	65.1% (160822)	71.3% (124688)	78.2% (86644)
	Female	2.5% (12523)	5.8% (20538)	49.0% (147675)	65.1% (160452)	71.3% (127858)	78.2 (116959)
	Both	2.5% (25511)	5.8% (41749)	49.0% (297597)	65.1% (321272)	71.3% (252544)	78.2% (203606)
2020	Male	2.5% (11862)	5.8% (21983)	49.0% (163585)	65.1% (177481)	71.3% (146381)	78.2% (109392)
	Female	2.5% (11356)	5.8% (21238)	49.0% (158922)	65.1% (178209)	71.3% (150128)	78.2% (135887)
	Both	2.5% (23218)	5.8% (43221)	49.0% (322506)	65.1% (355685)	71.3% (296507)	78.2% (245284)

Population prevalence estimates of musculoskeletal conditions (IPH, forthcoming)

Year	Characteristics							
	Gender	Age group % (number of cases)						
		18+	18-34	35-44	45-54	55-64	65-74	75+
Back condition clinical diagnosis % (number of cases)								
2010	Male	11.8% (192,443)	7.3% (40,588)	11.4% (37,956)	14.3% (40,534)	15.8% (35,806)	15.3% (21,470)	15.3% (16,091)
	Female	11.9% (202,625)	7.3% (42,357)	11.4% (37,648)	14.3% (40,406)	15.8% (35,587)	15.3% (22,589)	15.3% (24,037)
	Both	11.9% (395,070)	7.3% (82,948)	11.4% (75,604)	14.3% (80,939)	15.8% (71,392)	15.3% (44,059)	15.3% (40,128)
2015	Male	12.0% (208,668)	7.3% (37,595)	11.4% (41,491)	14.3% (43,780)	15.8% (38,979)	15.3% (26,768)	18.1% (20,056)
	Female	12.3% (212,958)	7.3% (36,249)	11.4% (40,175)	14.3% (43,124)	15.8% (38,889)	15.3% (27,448)	18.1% (27,073)
	Both	12.2% (421,626)	7.3% (73,844)	11.4% (81,666)	14.3% (86,903)	15.8% (77,868)	15.3% (54,215)	18.1% (47,129)
2020	Male	12.5% (224,870)	7.3% (34,336)	11.4% (43,002)	14.3% (47,769)	15.8% (43,017)	15.3% (31,425)	18.1% (25,321)
	Female	12.7% (227,698)	7.3% (32,870)	11.4% (41,544)	14.3% (46,408)	15.8% (43,193)	15.3% (32,229)	18.1% (31,454)
	Both	12.6% (452,568)	7.3% (67,206)	11.4% (84,546)	14.3% (94,177)	15.8% (86,209)	15.3% (63,653)	18.1% (56,776)
Osteoarthritis clinical diagnosis % (number of cases)								
2010	Male	2.7% (43,892)	0.2% (999)	0.6% (1,924)	2.8% (7,821)	5.3% (12,027)	8.7% (12,149)	10.1% (8,972)
	Female	5.7% (96,111)	0.4% (2,064)	1.2% (3,900)	5.5% (15,438)	10.7% (24,127)	16.7% (24,615)	19.6% (25,967)
	Both	4.2% (140,003)	0.3% (3,063)	0.9% (5,824)	4.1% (23,259)	8.0% (36,154)	12.8% (36,764)	15.8% (34,939)

2015	Male	3.0% (50,899)	0.2% (925)	0.6 % (2,103)	2.8% (8,448)	5.3% (13,093)	8.7% (15,147)	10.1% (11,183)
	Female	6.2% (107,927)	0.4% (1,767)	1.2% (4,162)	5.5% (16,476)	10.7% (26,366)	16.7% (29,910)	19.6% (29,246)
	Both	4.6% (158,826)	0.3% (2,692)	0.9% (6,265)	4.1% (24,924)	8.0% (39,459)	12.7% (45,057)	15.5% (40,429)
2020	Male	3.3% (58,592)	0.2% (845)	0.6% (2,180)	2.8% (9,217)	5.3% (14,449)	8.7% (17,782)	10.1% (14,119)
	Female	6.8% (122,019)	0.4% (1,602)	1.2% (4,304)	5.5% (17,731)	10.7% (29,284)	16.7% (35,119)	19.6% (33,979)
	Both	5.0% (180,612)	0.3% (2,447)	0.9% (6,483)	4.1% (26,948)	8.0% (43,733)	12.7% (52,902)	15.3% (48,098)
Rheumatoid arthritis clinical diagnosis % (number of cases)								
2010	Male	4.8% (79,032)	0.7% (3,717)	1.1% (3,600)	4.5% (12,805)	8.7% (19,759)	14.3% (20,026)	21.5% (19,124)
	Female	5.3% (89,492)	0.7% (3,879)	1.1% (3,571)	4.5% (12,765)	8.7% (19,638)	14.3% (21,070)	21.5% (28,568)
	Both	5.1% (168,523)	0.7% (7,597)	1.1% (7,171)	4.5% (25,570)	8.7% (39,397)	14.3% (41,096)	21.5% (47,691)
2015	Male	5.3% (91,523)	0.7% (3,443)	1.1% (3,935)	4.5% (13,831)	8.7% (21,511)	14.3% (24,968)	21.5% (23,836)
	Female	5.8% (99,993)	0.7% (3,320)	1.1% (3,810)	4.5% (13,624)	8.7% (21,461)	14.3% (25,603)	21.5% (32,176)
	Both	5.6% (191,517)	0.7% (6,763)	1.1% (7,746)	4.5% (27,455)	8.7% (42,971)	14.3% (50,570)	21.5% (56,012)
2020	Male	5.9% (105,459)	0.7% (3,145)	1.1% (4,079)	4.5% (15,091)	8.7% (23,739)	14.3% (29,312)	21.5% (30,094)
	Female	6.3% (112,892)	0.7% (3,010)	1.1% (3,940)	4.5% (14,661)	8.7% (23,836)	14.3% (30,062)	21.5% (37,383)
	Both	6.1% (218,352)	0.7% (6,155)	1.1% (8,019)	4.5% (29,753)	8.7% (47,574)	14.3% (59,373)	21.5% (67,478)

Appendix 5: Beverage definitions (Canadean, 2011)

The following definitions are based on those provided in the Canadean Report (2011).

Carbonates

Sweetened, non-alcoholic drinks containing carbon dioxide.

Other sweetened drinks

Nectars

Diluted fruit/vegetable juice and pulp, to which sweetening agents (e.g. sugar, honey, syrups and/or sweeteners), permitted minerals and vitamins for the purpose of fortification and permitted additives may be added.

Squash/Syrups

Non-ready-to-drink (non-rtd) products, marketed as concentrates for home consumption. The category includes fruit and non-fruit based products and flavours. All market figures shown in Canadean database and reports are expressed in ready to drink (rtd) volumes**.** Dilution ratio varies from country to country.

Still Drinks

Flavoured ready to drink, non-carbonated products, which may be fruit or non-fruit flavoured and have a juice content of 0-24.9%. Sugar, artificial flavouring and colouring may be added.

Sports Drinks

Performance-enhancing products, described as ‘isotonic', ‘hypertonic' or ‘hypotonic', meaning ‘in balance with', ‘lighter than' and ‘heavier than' body fluids, respectively. Products contain B complex group vitamins, such as:

- B1 Thiamin
- B2 Riboflavin
- B3 Niacin/niacinamide
- B5 Pantothenic acid
- B6 Pyridoxine hydrochloride
- B7 Biotin
- B12 Cyanocobalamin
- Choline

As well as vitamin E (i.e. antioxidant), and vitamin C (ascorbic acid), along with key electrolytes such as calcium, potassium, magnesium, sodium, glucose syrup, maltodextrin, sweeteners and acidity regulators (e.g. sodium citrate, calcium carbonate, calcium hydroxide).

Energy Drinks

Energy-enhancing products, mainly carbonated and containing stimulants such as caffeine, taurine, guarana (the guarana seed has a higher caffeine content than coffee), glucuronolactone, yerba mate, along with glucose

syrup (corn syrup) and maltodextrin. Includes B complex group vitamin combinations, typical examples include:

- B2 Riboflavin
- B3 Niacin/niacinamide
- B5 Pantothenic acid
- B6 Pyridoxine hydrochloride
- B7 Biotin
- B9 Folic acid
- B12 Cyanocobalamin
- Inositol

As well as vitamins A and E (i.e. antioxidants); vitamin C (ascorbic acid); L-carnitine; exotic herbs and substances, such as gingko biloba, ginseng, milk thistle; acidity regulators. Products may also contain juice e.g. Rockstar Juiced (70% juice content), Coca-Cola's Burn Juiced (20% juice content).

Other drinks

Bottled Water

Still - Non-carbonated unsweetened mineral, spring or table water, with or without added flavourings and vitamin/mineral enhancement.

Carbonated – carbonated unsweetened mineral, spring or table water, including low-carbonation waters, either naturally carbonated or which have been rendered carbonated by the injection of carbon dioxide, including 'low carbonation' waters. Includes carbonated water with and without added flavourings and vitamin/mineral enhancement.

Iced/Rtd Tea Drinks

Carbonated and non-carbonated ready to drink (rtd) packaged tea-based drinks and non-ready to drink (non-rtd) powders and liquid concentrates which dilute with water to make a product similar/identical to the ready to drink product. Includes products based on black, green, oolong, barley, rooibos, white and mate tea, as well as fruit, flower and herbal teas. Products can be cold or hot-filled and based on brewed tea or tea extract. They may contain additional flavourings, typically fruit, floral or herbal, fruit juice, sweeteners and other ingredients.

Iced/Rtd Coffee Drinks

Primarily non-carbonated packaged ready to drink (rtd) and non-ready to drink (non-rtd) coffee-based drinks. May be cold- or hot-filled, based on brewed coffee or coffee extract. Products may contain additional flavouring (e.g. vanilla, chocolate) as well as sweeteners and other ingredients, notably milk.

Calorie Rating

Low Calorie

Reduced calorie products marketed on a diet, reduced or low calorie platform and sweetened with high intensity agents, either single or blended. Will be highlighted on the product label as:

- diet/light/low calorie (<20 kcal/100ml)
- mid calorie (50% less calories than normal)
- sugar-free/zero/calorie free (<4kcal/100ml)
- no (added)/low/reduced sugar (4g sugar per 100ml/approx <20kcal per 100ml)

Appendix 6: Distribution definitions (Canadean, 2011)

Off-premise

Volume sold for 'subsequent consumption' away from the place of purchase, comprising:

Modern Retail:

Large Modern: Supermarkets, hypermarkets, department stores (Karstadt): modern facilities, typically with electronic tills, barcode scanning and multiple checkout.

Convenience: Stores such as 7-11, garage forecourts - typically small food stores with long opening hours, often selling ready meals and fast food.

Discount: Hard discounter stores, such as Lidl and Aldi, where focus is on low pricing.

Traditional Retail:

Traditional food stores: 'mom & pop' style, CTNs, delis, pharmacies/drugstores. Street stalls and kiosks (not for immediate consumption).

Specialist Beverage Retailer: Off-licences, liquor stores, specialist drinks shops.

Home Delivery: On-line/telephone/mail order, deliveries to home address.

On-premise

Volume sold for 'immediate consumption' at the place of purchase, comprising:

Vending: Automatic merchandising machines selling (usually) branded beverages.

QSR: Quick service restaurants. Payment is made prior to consumption.

EDA establishments: Eating, Drinking and Accommodation. Eating: establishments where beverage consumption is generally an accompaniment to a meal. Payment is made after consumption. Drinking: establishments primarily engaged in the sale of drinks for consumption on premise. Accommodation: establishments where the primary function is to provide accommodation facilities.

Institutions: Workplaces, hospitals, nursing homes, schools, universities, prisons, military.

Other on-premise: Such as cinemas, street stalls and kiosks, travel and transport, leisure (including gyms/health clubs) and events.

Appendix 7: Satiety Theory

The following is an extract from DiMeglio and Mattes (2000:798) offering an explanatory theory to the satiety question.

There are several mechanisms that may account for this phenomenon. The act of masticating the solid may provide an internal satiety signal not triggered by simply swallowing the liquid. Haber et al. [1] *reported higher satiety rating from individuals consuming apple slices that had to be chewed when compared to ratings after eating apple puree or drinking juice that required less mastication. Both early pancreatic exocrine and endocrine responses to oral stimulation with viscous or solid stimuli are greater than those to fluids.* [2-4] *Accumulating evidence indicates these early responses (e.g. insulin release) modulate post-prandial metabolism (e.g. glucose tolerance* [5-7]*) with potential resultant effects on hunger and feeding. A cephalic phase release of the purported satiety promoting peptide, cholecystokinin (CCK) has also been demonstrated with a solid meal* [8]*, but never contrasted to responses following oral exposure to a fluid.*
The large differences in the volume, energy density and osmotic properties of most liquids and solids could also be involved. Meals of larger volume, lower energy density and lower osmotic potential are emptied from the stomach at a more rapid rate [8-11]. *To the extent that gastric sensing elements for these properties generate signals influencing feeding, fluids may evoke weaker signals. The more rapid transit of fluids also results in different time course of exposure of nutrients to purported nutrient sensors in the gut or proximal duodenum with possible implications for meal initiation* [12, 13]. *However, the limited data from experimental manipulations of these variables in humans have not been associated with consistent shifts in reports of hunger and satiety* [11]. *Self-reported hunger and fullness ratings during the two treatment arms were also comparable in the present study.*
Cognitive influences could also contribute to the present findings. If solid foods are considered higher in energy content, this could lead to reduced intake. There are reports that the perceived energy content of a food is a better predictor of hunger and intake that true energy content [14]. *… …*
While the above hypothesized mechanisms focus on factors that may influence energy balance through modulation of hunger and feeding, discrepant metabolic and cardiovascular responses to liquid vs solid meals may contribute through an influence on energy expenditure. Metabolic rate and heart rate are higher acutely after ingestion of a solid meal as compared to an isoenergetic, high carbohydrate liquid meal [15].

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Appendix 8:

Modelling the effects of a 10% sugar sweetened drinks tax on obesity and overweight in Ireland: a report to inform the Health Impact Assessment

Report authors: Dr Adam Briggs, Dr Oliver Mytton, Dr Peter Scarborough and Dr Mike Rayner of the British Health Foundation Health Promotion Research Group, Department of Public Health, University of Oxford.

We (the British Heart Foundation Health Promotion Research Group) have been invited to model the effects of a 10% tax on sugar sweetened drinks (SSDs) in Ireland on obesity and overweight, and to describe the effects by age, income group, and consumption (regular consumers of carbonated SSDs compared to low consumers or carbonated SSDs). The report is to inform the Health Impact Assessment (HIA) of a proposed 10% tax on SSDs in Ireland. This paper outlines our methods, describes our findings and discusses the limitations of this work.

All queries concerning this work should be directed to Dr Mike Rayner (mike.rayner@dph.ox.ac.uk).

Contents

Executive Summary

- Sugar sweetened drinks (SSDs) are here defined as non-alcoholic drinks served cold with added sugar (both carbonated and non-carbonated).
- This paper uses a standard approach to model the effects of a 10% tax on SSDs in Ireland. It applies international estimates for the consumption response to price rises to Ireland (using local data on consumption of SSDs). From this reduction in consumption a reduction in calorie intake is estimated.
- A set of validated equations that describe the relationship between energy balance and body weight are used to predict the effects of a calorie reduction on weight (and body mass index) in Ireland.
- The 10% tax on the price of SSDs is predicted to reduce the number of obese adults (defined as a body mass index (BMI) ≥30kg/m^2) by around 10,000 (95% credible intervals: 7,000 to 13,000) and the number of adults who are overweight, including obese, (BMI≥25kg/m^2) by 14,000 (10,000 to 18,000). This represents a reduction in obesity of 1.25% and in overweight, including obese, of 0.67%.
- The average reduction in energy intake in the adult population of Ireland, as a result of the tax is predicted to be 2.1 kcal per day, or 15 kcal per week; the predicted reduction is greater in the young (e.g. 32 kcal calories per week in those aged 18-24) and in regular drinkers of carbonated SSDs (35 calories per week).
- The impact of the tax across income groups[71] (in terms of obesity) is broadly similar. While obesity shows a gradient across income groups this is slight (a prevalence of 14% in those with the highest income compared with 17% in those with the lowest), SSD consumption is relatively uniform across income groups so no discernible differences between groups are noted. Different price responses by different economic groups are not modelled.
- Of the 10,000 fewer obese adults, approximately 80% are regular consumers

[71] The impact here refers to both the relative and absolute effects.

Of carbonated SSDs (3.3 % reduction in obesity among regular consumers who are obese compared to a 0.5% reduction among low consumers who are obese).

- The impacts on men and women are similar with a predicted reduction of 5,300 fewer women with obesity and 4,600 fewer men with obesity.
- Data on SSD consumption and obesity (self-reported height and weight) in Ireland is taken from Survey on Lifestyle and Attitude to Nutrition (SLAN) 2007. Obesity estimates (based on self-reported height and weight) have been adjusted upwards to make allowance for under-reporting (in comparison with measured height and weight from SLAN 2007 and Irish Universities Nutrition Alliance survey (IUNA, 2011). Estimates of SSD consumption are lower in SLAN 2007 than in IUNA 2011 (45ml/day/person vs. 82g/day/person).
- As with any modelling exercise a series of assumptions are made (and these are set out in the full body of the report). The principal area of uncertainty is the extent to which SSDs would be replaced with other drinks when the price of SSDs rises (and what the calorie content of these drinks will be) – there is no data to describe this in Ireland. Significant substitution with caloric drinks (e.g. fruit juice) would mitigate the effects on obesity. Significant substitution with non-caloric drinks (e.g. water or 'diet drinks') would not have a meaningful effect on the estimates in this report.
- The effects of a 10% tax on obesity could be greater than estimated in this report (e.g. due to higher price elasticity or higher consumption of SSDs). The effects on obesity could be less than estimated in this report (e.g. compensatory increase in consumption of foods or other caloric beverages or lower pass on rate of the tax to consumers)

Introduction

Estimates of the magnitude (and likely success) of health benefits from any policy are an important part of informing decision making on health policy. Three potential approaches have been outlined to test efficacy of and understand the

magnitude of any health benefits due to a health-related food tax (Mytton, 2012): natural experiments, controlled trials and modelling.

Each approach has its limitations. While natural experiments may provide the strongest evidence, it can be particularly hard to disentangle the impact of other co-incident changes on the measured outcome. This is a particular problem in complex systems and when the anticipated effect sizes are small. Unfortunately few, if any studies, have addressed this question well.

The USA, where many states have introduced taxes on SSDs, may provide some insight, although some suggest the sales taxes in the states are too low to have any meaningful impact. One longitudinal study reported a greater rise in obesity prevalence in states with no soft drinks tax (odds ratio = 4.2, 95% CI: 0.4-48.3) and states that had repealed the tax (odds ratio = 13.3, 95%CI: 0.7-262) compared to states with a soft drinks tax, although the results were not significant (Kawachi, 2006). A second cross-sectional study found no association between the presence of sales taxes on SSDs and prevalence of obesity at a state level (Powell, 2009). This study had limited ability to answer the question (it might either be expected that states who have implemented a tax would see lower obesity levels, conversely it might be expected that states with a tax might have higher obesity rates, as they would implement the tax in response to the problem). Even in the absence of strong positive effects (or indeed a negative result) the effects in a different setting (Ireland) may be very different to the USA.

Controlled trials (e.g. having a simulated grocery store where prices are manipulated; or manipulating the cost of soft drinks in a hospital canteen) have been widely used to explore the likely changes in consumption resulting from a tax rise on unhealthy food items (or indeed subsidies on healthy food items). A recent systematic review points to strong and consistent results for a reduction in the purchasing of unhealthy food items following an increase in the price (Epstein, 2012). However it is unclear how well simulated environments where artificial constraints, fixed budgets and restricted choices imposed on subjects predict

actual life choices. The health benefits accrue in the long term, so are not captured by these short term studies.

Modelling is a technique for estimating the likely beneficial (and harmful) changes from a given hypothetical scenario, such as the introduction of food taxes or subsidies. Modelling studies have been used for many years to inform many areas of government policy as well as strategic decision making within companies and organisation. It quantifies the benefits to human health from policy changes to inform decision making. These benefits (or harms) can be compared against other anticipated effects from a given policy change (e.g. financial, employment). It also allows understanding and quantification of the likely differential impacts of policy measures between groups within society.

Modelling requires a set of inputs into the model and a series of assumptions to be made in order to derive final estimates of effect. Uncertainty in the results of modelling projects can be introduced in two ways: structural uncertainty and parametric uncertainty. Structural uncertainty refers to whether the assumptions involved in the model's design are an appropriate reflection of the real-life situation. The degree to which model results are sensitive to these structural assumptions can be assessed with sensitivity analyses. Parametric uncertainty refers to the quality of evidence used to link the different stages in the model (e.g. the degree to which the model predicts an increase in blood pressure as a result of an increase in salt consumption). The total amount of parametric uncertainty attached to results from a model can be assessed using uncertainty analyses. Even when appropriate sensitivity and uncertainty analyses have been conducted, there is always room for discussion and disagreement around the validity of the assumptions and inputs used in a model. The limitations of this particular work are considered in the discussion section of this paper.

Dr Peter Scarborough (of the BHF Health Promotion Research Group) has been developing models for use in public health for the past five years. The work presented here uses the PRIME model (Preventable Risk Integrated ModEl). It is a

comparative risk assessment model, based on methods for assessing comparative risk developed by the World Health Organization's Global Burden of Disease Project (WHO, 2012). The purpose of the model is to estimate the population change in deaths from 26 chronic diseases that would result from changes in the behavioural risk factor profile of the population of interest. Papers using the model have been published widely (Scarborough, 2012a; Scarborough, 2011; Scarborough, 2012b; Nichols, 2012). The model is increasingly being used by groups both in the UK and abroad, to understand and test the potential benefits of different programmes to modify behavioural risk factors for health. Early versions of the model have been used in modelling the health effects of health-related taxes (Mytton, 2007; Nnoaham 2009). In this report we model the effects of a 10% tax on SSDs in Ireland using the PRIME model.

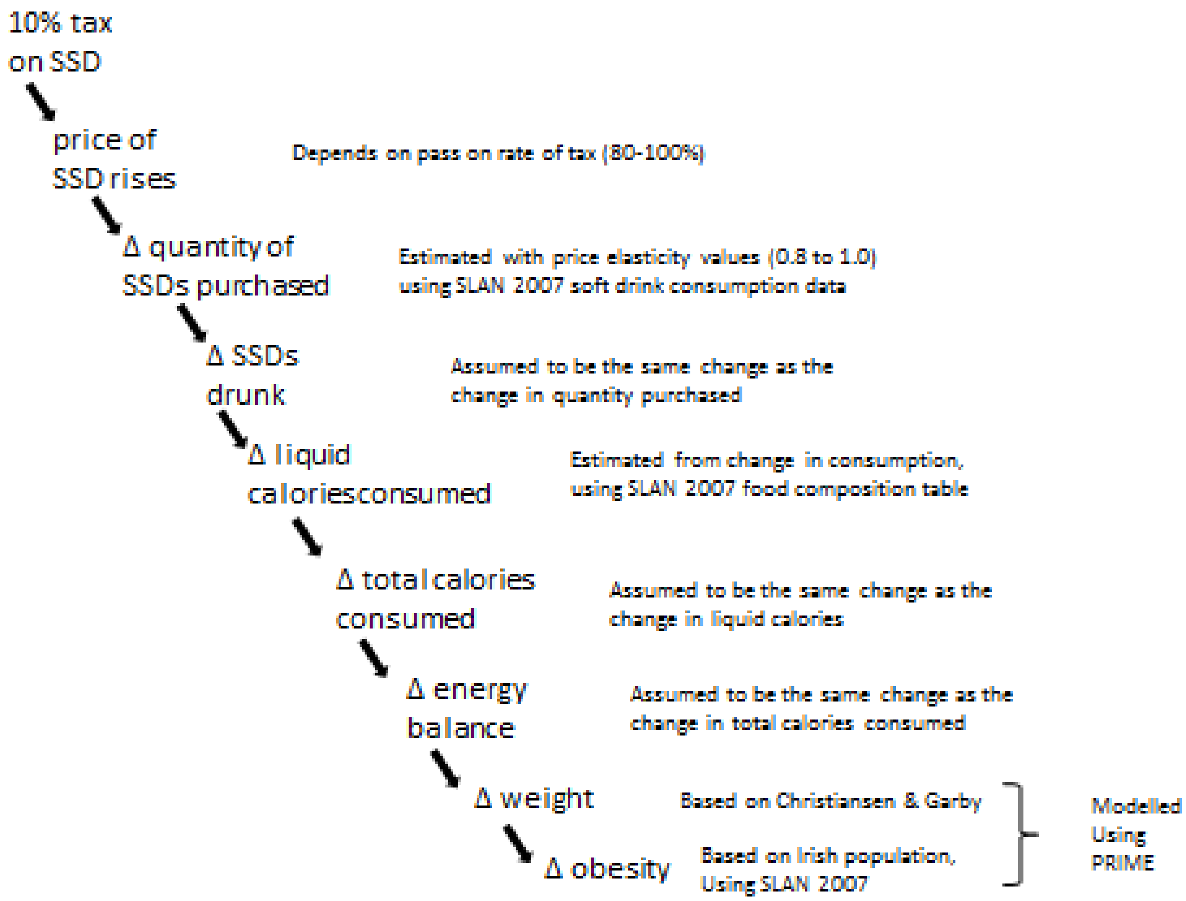
Methods

We use estimates of the price elasticity of sugar sweetened drinks (SSDs) to estimate the effects of a 10% tax on the purchasing (and consequent consumption) of SSDs in Ireland. The estimated changes in calorie intake (from the changes in SSD consumption) and consequent change on energy balance are used to estimate the effects on obesity. This approach has been commonly used to estimate the effects of taxation on SSDs (Andreyeva, 2011; Lin, 2011; Dharmasena, 2011).

Price elasticity estimates are based on the international literature. Estimates of SSD consumption and obesity prevalence are taken from the Survey on Lifestyle and Attitude to Nutrition SLAN (2007), a representative survey of the Irish population.

The full causal pathway and key assumptions used within the model are set out below.

Figure 1: Assumed causal pathway for the effect of a 10% SSD tax on obesity in Ireland



Estimating the change in SSD consumption

Price elasticity measures the responsiveness of consumption (purchasing) of a good when prices change. Own price values refer to the change in consumption that occurs for a given good when the price of that same good alters. Cross-price values refer to the change in consumption that occurs for a given good when the price of another good alters (e.g. the consumption of cream when the price of strawberries changes).

There is a large amount of international literature on the own price elasticity of demand for SSDs. A systematic review of food price elasticity data quoted a mean price elasticity of demand for soft drinks of -0.79 (range 0.13-3.18), averaged across 14 studies (Andreyeva, 2010). Ireland had a special excise tax on SSDs in the 1980s,

and it was estimated that the price elasticity of demand for soft drinks in Ireland, as a result of this tax was 1.10. Here we assume an own-price elasticity of 0.9 for SSDs (i.e. a 10% price rise causes consumption to fall by 9%). We take a range of 0.8 to 1.0 when undertaking sensitivity analyses.

We were not able to find reliable estimates for price-elasticity values by age, sex, socio-economic group and consumption to use in the model (although there are likely to be differences in price-elasticity values by population sub-group). Although we model differential effects between income groups, these are based only on differences in obesity and SSD consumption between income groups and not differential responsiveness to price changes.

We do not include cross-price elasticity measures in our model. Cross-price data would allow us to estimate the effect of such a tax on other drink (and food) products, such as the effect of the tax on consumption of substitutes (drinks with artificial sweetener, bottled water, fruit juices, milk, tea and coffee). We are not aware of any cross-price estimates for Ireland. While such data has been used to estimate the impact of a SSD tax in the USA on calorie consumption, we did not feel it would be appropriate to use these values in the Irish setting as such values are likely to be very context specific (e.g. depending on baseline levels of consumption).

There are no documented studies on the extent to which a tax on SSDs would be passed onto the consumer. The manufacturer may choose to absorb some of the cost, restricting the price passed onto the consumer. Equally in some markets, the manufacturer may pass on more than the cost of the tax to the consumer in a price rise. In a competitive industry, with many firms operating, it is assumed that 100% of the tax rise would be passed onto consumers. In a concentrated industry where a few firms are responsible for a large proportion of sales, the assumption of 100% pass on is less likely. Research by Bahl (2003) suggested that the pass on rate for soft drinks will be less than 100%, but did not quantify the magnitude of the pass on. Here we assume that 90% of the 10% tax will be passed on to the consumer

(i.e. a 10% tax would generate a 9% price rise). We take a range of 80 to 100% for undertaking a sensitivity analysis.

Combining an own-price elasticity of 0.9 with a 'pass-on rate' of 90% would mean an average reduction in consumption of SSDs by 8.1% as a result of the 10% tax. Others who have modelled the effects of a 10% tax on SSDs, directly using price elasticity values, have assumed similar (Andreyeva, 2011) or greater reductions (Lin, 2011, Dharmesena, 2011).

Estimating consumption of sugar sweetened drinks and obesity in Ireland

The Survey on Lifestyle and Attitude to Nutrition (SLAN, 2007) dataset is used to estimate SSD consumption (from a food frequency questionnaire) and obesity prevalence in Ireland (by age, sex, socio-economic group and income group[72]). The SLAN dataset is considered representative of the Irish population. It is also the biggest survey of health in Ireland (n=10,364), being frequently cited for official statistics on health in Ireland.

We also considered basing the modelling on the Irish Universities Nutrition Alliance (IUNA) dataset. The form and methodologies for the two datasets are broadly similar. While the IUNA dataset is more recent (2011) it is also smaller (n=1,500). Using this smaller dataset would significantly reduce our ability to model the effects of the tax by sub-groups (where the number of observations for any sub-group will be much less), particularly for age and socio-economic status. For this reason the SLAN dataset is used in the modelling. A fuller discussion on the differences in estimates of obesity and SSD consumption, and how this may change the overall estimates is included in the discussion section.

Sugar Sweetened Drinks

The SLAN survey records self-reported consumption of carbonated SSD (from here after referred to as carbonated SSDs) and non-carbonated SSD (referred to as non-carbonated SSDs). Diet or low calorie drinks are counted separately. For the

[72] Income group is based on net household income.

purpose of our modelling these two categories are combined into one category: sugar sweetened drinks (SSDs). Data on drinks consumption in Ireland (based on SLAN, 2007) have not previously been published by age and sex. Consequently these estimates (which serve as an input into the model) are included in the results. The estimates of overall population consumption are weighted by age and sex.

Obesity

Only a sub-sample of the SLAN dataset had a measured BMI (both measured height and weight) (n=2,174). For this reason self-reported BMI (calculated from self-reported height and self-reported weight) is used to provide estimates of the proportion of the population who are overweight or obese. Using this much larger sample, with self-reported BMI, allows us to make age and income group specific estimates of reduction in obesity.

Self-reported BMI in the SLAN dataset underestimates the true BMI of the population (Shiley, 2010). In this report we present estimates on the effect of obesity and overweight based both on self-reported height & weight and on measured height & weight. The age and sex specific estimates of the impact of the tax on obesity and overweight are based on self-reported data. Two set of overall estimates (for the whole population) are presented, one based on self-report, and a second (adjusted) based on measured height & weight.

The age and sex specific estimates of the impact of the tax on obesity and overweight are used to calculate an overall figure for the (unadjusted) impact on obesity (and overweight). This (unadjusted) figure is then adjusted for measured percentage of total obese men and women in comparison with the self-reported percentage of obese men and women. This gives an overall (or headline) estimates of the impact of the tax on obesity are adjusted for the under-reporting of BMI by self-report.

Modelling the calorie change

We derive the estimated change in volume of SSD consumption by applying the percentage change in consumption (following the introduction of the tax) to the baseline SSD consumption. The standard food composition table for the SLAN dataset (values shown in the appendix) is used to estimate the change in calorie consumption by applying the calorie density (number of calories per 100g) to the change in volume consumed.

Modelling the changes in obesity

We use the PRIME model to estimate the changes in obesity and overweight due to the change in calories at a population level. The PRIME model is a comparative risk assessment model. The model has previously been used to estimate changes in mortality from chronic disease deaths due to potential changes in diet and other health-related behaviours in the UK (Scarborough, 2012a; Scarborough, 2011; Scarborough, 2012b; Nichols, 2012).

For the purpose of modelling a tax on SSDs in Ireland, the input for the PRIME model is restricted to changes in the total calorie intake of the Irish population (or sub-group within the population), and the output is restricted to changes in the distribution of BMI in the Irish population (or sub-group within the population). The equations that the PRIME model uses for these estimates are drawn from a study that explored changes in body weight based on principles of conservation of energy, and the effect of body weight on the composition of the body as fat and fat free mass (Christiansen, 2002). Importantly, the equations predict the new 'steady state' body weight that is achieved if either total calorie intake or physical activity levels (or both) were to change. These equations allow for change in the basal metabolic rate and the distribution of fat and lean mass within the body as weight changes. The equations do not predict how long it will take to achieve this new steady state.

A variety of different approaches to calculating the change in body weight for a given change in calorie intake have been advocated. The traditional 'rule of thumb'

assumes that 3500 calories removed from the diet would equate to one pound (0.45kg) of weight loss because the energy released by burning one pound of fat is 3500 calories. This has been criticised as it does not make allowance for reductions in the body's basal metabolic rate as weight loss occurs and energy intake is reduced (Hall, 2011).

Several dynamic (or steady state) models (that make allowance for changes in basal metabolic rate) were considered for incorporation into the PRIME model (Swinburn, 2009; Kozusko, 2002; Heymsfield, 2007; Christiansen, 2002; Hall, 2008). Christiansen (2002) was chosen for inclusion in PRIME because it performed well in a validation exercise (Hall, 2008), used readily measurable and reported inputs, and was computationally simpler (not requiring iterative functions). In a comparison exercise of Christiansen (2002) vs. Hall (2011), the two models perform similarly over small changes (see appendix 2). For the purposes of the PRIME model the greater accuracy of the Hall model was felt to be slight, and out-weighed by the greater computational burden. The primary difference is that Christiansen (2002) tends to overestimate weight loss in those at a low BMI (below 25kg/m3) and underestimate weight loss at high BMI (above 35kg/m3) in comparison with Hall (2011). In the range 25-35kg/m3 there is fairly good agreement between the models. Examples of the weight loss predicted by these different models, based around the observed calorie changes from the modelling, are included in the appendix.

Different equations are used for men and women, and are dependent solely on change in total energy intake and change in physical activity levels (for the purpose of the modelling conducted here, we assume that average physical activity levels remain unchanged at a PAL of 1.6). The equations reported in the paper are:

$$\Delta Body\ Weight_{men} = 17.7 \times \Delta\left(\frac{Energy\ intake}{Physical\ activity\ level}\right)$$

$$\Delta Body\ Weight_{women} = 20.7 \times \Delta\left(\frac{Energy\ intake}{Physical\ activity\ level}\right)$$

Energy intake is measured in MJ per day; physical activity level is measured as the ratio between total energy expenditure and resting energy expenditure; body weight is measured in kg.

Population Estimates

Where estimates of the total number of people within in Ireland are given these are based on Irish population data taken from the 2011 census.

95% credible intervals

The 95% credible intervals around estimates of changes in the prevalence of obesity are provided by a Monte Carlo analysis which allows the risk parameters (17.7 for men, and 20.7 for women in the above equations) to vary according to the distribution described in the original article (Christiansen, 2002). Running the Monte Carlo analysis is time intensive, therefore credible intervals are only provided for the primary results of the analysis, and point estimates only are provided for secondary results.

Sensitivity Analysis

We undertake a sensitivity analysis around some of the assumptions:

- Varying the price elasticity of demand from 0.8 to 1.0
- Varying the pass on rate of the tax from 80% to 100%

Results: Descriptive data on obesity and SSD consumption in Ireland

<u>SSD consumption in Ireland</u>

In 2007, Irish women were consuming an average (mean) of 160kcal per week from SSDs (400ml or 90kcal of carbonated SSD and 280 ml or 70kcal of non-carbonated SSD), and men an average of 200kcal (580ml or 140kcal of carbonated SSD and 260 ml or 60kcal of ' fruit squash'). Around 4 in 10 adults were regularly drinking (at least once per month) carbonated SSD, although this figure rose to nearly 7 in 10 for young adults (aged 18-24 years). Regular consumption declined with age (table 1).

Table 1: Carbonated SSD – proportion of the population who are regular consumers in Ireland in 2007

Age	Overall	Male	Female
18-24	68%	71%	65%
25-34	54%	61%	47%
35-44	43%	51%	36%
45-54	35%	41%	29%
55-64	24%	26%	22%
65-74	17%	19%	16%
75+	16%	16%	16%
Overall	40%	46%	35%

Regular consumption is defined as consumption at least one carbonated soft drink per month. Overall estimates are adjusted for age and sex.

<u>Obesity and overweight in Ireland</u>

In 2007, the proportion of the adult population who were obese based on self-reported height and weight was 14% (495,000 individuals based on 2011 population estimates), and who were overweight, including obese, was 50% (1,734,000 individuals). The published figures from SLAN 2007 (based on the sub-set of the sample with measured height and weight) reported a prevalence of obesity of 23% (791,000) and overweight, including obese, of 61% (2,098,000).

Obesity and overweight in 2007 (both measured and self-report) showed a rise with age, a peak and plateau in middle-age, and a decline in older age (table 2, table 3 and table 4).

Table 2: Number of adults who are obese in Ireland based on self-reported data in 2007 (BMI ≥ 30 kg/m2)

Age	Number obese (% of that age-group)		
	Overall	Male	Female
18-24	27,500 (7%)	10,600 (5%)	16,800 (8%)
25-34	86,100 (11%)	47,500 (13%)	38,700 (10%)
35-44	105,700 (15%)	59,300 (17%)	46,100 (13%)
45-54	117,700 (20%)	60,500 (21%)	57,400 (20%)
55-64	89,900 (19%)	47,600 (21%)	42,600 (18%)
65-74	48,500 (16%)	28,900 (19%)	19,500 (13%)
75+	18,200 (8%)	7,800 (8%)	10,400 (8%)
All adults	495,300 (14%)	262,800 (16%)	231,600 (13%)

Numbers may not sum exactly due to rounding. Overall estimates are weighted by age and sex for the Irish population.

Table 3: Numbers of adults who are overweight including obese in Ireland based on self-reported data in 2007 (BMI ≥ 25 kg/m2)

Age	Number overweight including obese (% of that age-group)		
	Overall	Male	Female
18-24	101,100 (25%)	54,500 (27%)	46,700 (23%)
25-34	335,300 (44%)	196,400 (53%)	138,800 (36%)
35-44	376,000 (54%)	233,200 (67%)	142,800 (41%)
45-54	351,800 (61%)	203,500 (71%)	148,000 (51%)
55-64	293,300 (63%)	164,000 (71%)	129,100 (56%)
65-74	174,700 (57%)	96,500 (64%)	78,100 (50%)
75+	101,700 (44%)	48,700 (52%)	52,900 (39%)
All adults	1,733,500 (50%)	997,500 (59%)	737,000 (42%)

Numbers may not sum exactly due to rounding. Overall estimates are weighted by age and sex for the Irish population.

Table 4: Proportion of adults who are overweight including obese in Ireland based on measured data (taken from the SLAN, 2007 report)

	Percentage overweight including obese (BMI ≥ 25 kg/m2)	Percentage obese (BMI ≥ 30 kg/m2)
18-29	38%	11%
30-44	61%	22%
45-64	77%	32%
65+	71%	30%
Men	67%	22%
Women	56%	24%

Data taken from the SLAN, 2007 report

Obesity and overweight in Ireland: by income and social class

In 2007, obesity showed a socio-economic gradient in Ireland. For both sexes the prevalence of obesity fell with rising income and fell with rising social status (as measured by occupational group). Looking at overweight, including obese, the pattern differed by sex. Women showed a similar pattern, a fall in overweight

including obese with rising income and with rising socio-economic status. Men showed the opposite pattern, a rise in overweight including obese with rising income and rising socio-economic status.

Table 5: Prevalence of obesity and overweight in Ireland by social class and income in Ireland in 2007

Social Class/Income	Percentage of adults who are obese (percentage who are overweight or obese)		
	Overall	Male	Female
SC 5-6 (lowest)	16% (51%)	18% (58%)	15% (45%)
SC 3-4	15% (51%)	17% (60%)	14% (43%)
SC 1-2 (highest)	13% (51%)	14% (62%)	11% (40%)
Income group 1 (lowest)	17% (50%)	18% (54%)	15% (46%)
Income group 2	16% (50%)	17% (58%)	14% (43%)
Income group 3 (highest)	14% (51%)	15% (63%)	12% (40%)

SC =social class group (1-2 = professional and managerial; 3-4 = non-manual and skilled manual; 5-6 = semi-skilled and unskilled); Incomes groups are based on level of net household income and are grouped as follows: Group 1: <€19,999 per year; Group 2: €20,000-€39,999 per year; Group 3: >€40,000 per year. Estimates for males and females are weighted for age for the Irish population, and overall estimates are weighted for age and sex of the Irish population.

<u>Obesity and overweight in Ireland: by consumption of carbonated SSD</u>

In 2007, the prevalence of overweight including obese was similar among regular consumers and low consumers of carbonated SSDs.

Table 6: Prevalence of obesity and overweight in Ireland comparing regular consumers and low consumers of carbonated SSDs in 2007

Age	Percentage obese, BMI≥30 (percentage overweight including obesity, BMI≥25)	
	Regular consumers	low consumers
18-24	6% (24%)	8% (25%)
25-34	11% (42%)	13% (48%)
35-44	16% (56%)	16% (53%)
45-54	20% (64%)	19% (60%)
55-64	19% (62%)	19% (63%)
65-74	12% (59%)	17% (58%)
75+	8% (49%)	8% (43%)
Overall	14% (51%)	15% (51%)

Regular consumption is defined as consumption at least one drink per month of carbonated SSDs. Estimates for each age group are weighted for sex; and the overall estimate is weighted for age and sex of the Irish population.

Results: Modelling the effects of a 10% SSD tax in Ireland

<u>Estimated reduction in calorie intake</u>

We estimate that a 10% tax on SSDs will result in an average (mean) calorie reduction of 2.1kcal/person/day (table 7). This is equivalent to a mean reduction of 15kcal a week, or 770kcal a year per head of adult population. The reductions in calorie intakes are slightly greater in men than women (mean of 2.3kcal/person/day compared with a mean of 1.9kcal/person/day), reflecting higher levels of SSD consumption among men. Reductions in calorie intakes are also greater among the young (table 7) and regular consumers of carbonated SSD (table 9).

Table 7: Estimated calorie reduction from a 10% tax on SSDs in Ireland by age

Age	Mean reduction in daily calorie intake (kcal/person/day)		
	Overall	Males	Females
18-24	4.2 (3.3 to 5.2)	4.7 (3.7 to 5.8)	3.7 (2.9 to 4.5)
25-34	2.9 (2.3 to 3.5)	3.1 (2.4 to 3.8)	2.7 (2.1 to 3.3)
35-44	2.2 (1.7 to 2.7)	2.2 (1.7 to 2.7)	2.2 (1.7 to 2.7)
45-54	1.5 (1.1 to 1.8)	1.6 (1.3 to 2.0)	1.3 (1.0 to 1.6)
55-64	1.2 (0.9 to 1.4)	1.3 (1.0 to 1.6)	1.0 (0.8 to 1.2)
65-74	0.9 (0.7 to 1.1)	1.3 (1.0 to 1.6)	0.5 (0.4 to 0.7)
75+	0.8 (0.6 to 1.0)	0.9 (0.7 to 1.1)	0.7 (0.6 to 0.9)
Overall	2.1 (1.7 to 2.6)	2.3 (1.8 to 2.9)	1.9 (1.5 to 2.3)

Estimates are based on a tax pass on rate of 90%, price elasticity of 0.9 (range is for 80% and 0.8 respectively & 90% and 0.9). Estimates for each age group are weighted for sex; and the overall estimate is weighted for age and sex of the Irish population

Reductions in calorie intake by socio-economic status (social class and income) show different patterns among women and men. There is a trend for decreasing reductions in calorie intake with increasing socio-economic status. Women in the lowest social economic group (both social class and lowest income group) experience the greatest reductions. The trend for men is less evident, with men in the highest income groups experiencing the greatest reduction in calorie intakes but men in the highest social class experiencing the lowest reductions (table 8).

The mean daily calorie reduction among regular consumers of carbonated SSD is 5.0kcal/person/day (table 9). This is equivalent to a mean reduction of 35kcal a week and a mean reduction of 1825kcal a year.

Table 8: Estimated daily calorie reduction from a 10% tax on soft drinks in Ireland by income and socio-economic group

Social Class/Income	Mean reduction in daily calorie intake (kcal/person/day)		
	Overall	Male	Female
SC 5-6 (lowest)	2.2	2.4	2.1
SC 3-4	2.2	2.5	1.9
SC 1-2 (highest)	1.9	2.2	1.6
Income group 1 (lowest)	1.9	1.6	2.2
Income group 2	1.9	1.9	1.9
Income group 3 (highest)	2.3	2.6	1.9

SC =social class group (1-2 = professional and managerial; 3-4 = non-manual and skilled manual; 5-6 = semi-skilled and unskilled); Incomes groups are based on level of net household income and are grouped as follows: Group 1: <€19,999 per year; Group 2: €20,000-€39,999 per year; Group 3: >€40,000 per year. Estimates are based on a tax pass on rate of 90%, price elasticity of 0.9. Estimates for each age group are weighted for sex; and the overall estimate is weighted for age and sex of the Irish population

Table 9: Estimated daily calorie (kcal) reduction from a 10% tax on soft drinks in Ireland comparing regular consumers and low-consumers of carbonated SSD

	Calorie Reduction (kcal/person/day)	
	Regular consumers	Low consumers
Male	5.2	0.7
Female	4.9	0.8
Overall	5.0	0.7

A reduction in calories is seen for non-consumers of carbonated drinks due to a reduction in fruit squash consumption. Estimates are based on a tax pass on rate of 90% and price elasticity of 0.9. Estimates for each age group are weighted for sex; and the overall estimate is weighted for age and sex of the Irish population

Estimated reduction in obesity and overweight

The reductions in calorie intake are predicted to reduce the number of adults who are obese by 6,170 (1.25% of those who are obese). The number of overweight including obese is predicted to decrease by 11,650 (0.67% of those who are overweight including obese). These estimates are based on self-reported height and weight. After adjustment for under-reporting, the model predicts 9,900 fewer obese adults, and 14,400 fewer overweight, including obese, adults.

The reductions in obesity prevalence are similar among men and women. The reductions are greater in young adults compared to older adults. The greatest relative reduction occurs in those aged 18-24 years, and greatest absolute reduction in those aged 25-34 years (table 10). The reductions in overweight including obese prevalence are shown in table 11.

Table 10: Reduction in obesity by age and sex (BMI ≥ 30kg/m2)

Percentage reduction in obesity (number fewer obese)			
Age	Overall	Males	Females
18-24	2.9% (790)	3.3% (350)	2.4% (410)
25-34	2.1% (1,790)	2.0% (940)	2.2% (850)
35-44	1.4% (1,510)	1.3% (780)	1.6% (730)
45-54	0.8% (980)	0.9% (540)	0.8% (440)
55-64	0.7% (660)	0.8% (360)	0.7% (290)
65-74	0.6% (290)	0.7% (200)	0.5% (90)
75+	0.6% (110)	0.7% (50)	0.5% (60)
Overall	1.25% (6,170) (95% CI: 4,240 to 8,060)	1.24% (3,250) (95% CI: 2,310 to 4,200)	1.26% (2,920) (95% CI: 1,920 to 3,860)
Overall (adjusted)	1.25% (9,900) (95% CI: 6,750 to 12,940)	1.24% (4,600) (95% CI: 3,260 to 5,920)	1.26% (5,310) (95% CI: 3,490 to 7,020)

Estimate is based on a tax pass on rate of 90%, price elasticity of 0.9. Numbers may not sum due to rounding. Adjusted results are scaled up for under-reporting of obesity; they are derived assuming a baseline prevalence of male obesity of 22% and female obesity of 24% (compared to 16% and 13% respectively in the unadjusted results). Estimates for each age group are weighted for sex; and the overall estimate is weighted for age and sex of the Irish population

Table 11: Reduction in overweight, including obese, people by age and sex (BMI ≥ 25kg/m2)

% reduction in overweight including obese (reduction in number)			
Age	Overall	Males	Females
18-24	2.7% (2,770)	2.7% (1,450)	2.8% (1,320)
25-34	1.1% (3,660)	0.9% (1,680)	1.4% (1,980)
35-44	0.6% (2,380)	0.4% (1,010)	1.0% (1,370)
45-54	0.4% (1,270)	0.3% (640)	0.4% (630)
55-64	0.3% (800)	0.2% (400)	0.3% (400)
65-74	0.3% (450)	0.3% (280)	0.2% (170)
75+	0.2% (250)	0.2% (120)	0.3% (140)
Overall	0.67% (11,650) (95% CI: 7,930 to 15,250)	0.56% (5,630) (95% CI: 3,890 to 7,230)	0.82% (6,030) (95% CI: 4,040 to 8,020)
Overall (adjusted)	0.67% (14,380) (95% CI: 9,790 to 17,820)	0.56% (6,320) (95% CI: 4,400 to 8,180)	0.82% (8,060) (95% CI: 5,390 to 9,640)

Estimate is based on a tax pass on rate of 90%, price elasticity of 0.9. Numbers may not sum due to rounding. Estimates for each age group are weighted for sex; and the overall estimate is weighted for age and sex of the Irish population. Adjusted results are scaled up for under-reporting of overweight and obesity; they are derived assuming a baseline.

Estimated reduction in obesity and overweight: by income and SSD consumption

Different patterns for the reduction in obesity by income are seen for men and women. For women the greatest reductions[73] in obesity are seen for women in the

[73] This refers to relative reductions.

lowest income groups. For men the greatest reductions3 in obesity are in the highest income group, with a positive trend across the income groups (table 11). The percentage reduction in obesity among regular consumers of carbonated SSDs is greater than the reductions among low consumers of carbonated SSDs (3.3% vs. 0.5%; table 12).

The corresponding data for obesity and overweight are shown in table 14 and table 15.

Table 12: Percentage reduction in obesity by income group (95% credible intervals)

	Overall	Male	Female
Income group 1 (lowest)	1.1% (0.7% to 1.4%)	0.7% (0.5% to 1.0%)	1.4% (1.0% to 1.9%)
Income group 2	1.1% (0.7% to 1.4%)	1.0% (0.7% to 1.3%)	1.2% (0.8% to 1.6%)
Income group 3 (highest)	1.4% (0.9% to 1.8%)	1.5% (1.0% to 1.9%)	1.2% (0.8% to 1.6%)

Incomes groups are based on level of net household income and are grouped as follows: Group 1: <€19,999 per year; Group 2: €20,000-€39,999 per year; Group 3: >€40,000 per year. Estimates are based on a tax pass on rate of 90% and price elasticity of 0.9. Numbers of fewer obese are not presented because true underlying Irish population structure for each income group by age is not known.

Table 13: Percentage reduction in obesity for regular consumers and low consumers of carbonated SSD (95% credible intervals)

	Overall	Male	Female
Low consumers	0.5% (0.3% to 0.6%)	0.4% (0.2% to 0.4%)	0.6% (0.4% to 0.7%)
Regular Consumers	3.3% (2.3% to 4.4%)	3.2% (2.3% to 4.2%)	3.4% (2.3% to 4.6%)

A reduction in obesity prevalence is seen for low consumers of carbonated drinks due both to a reduction in fruit squash consumption and a small reduction in consumption of drinks with added sugar. Estimates are based on a tax pass on rate of 90% and price elasticity of 0.9. Numbers of fewer obese are not presented because underlying Irish population structure by for each income group by age is not known.

Table 14: Percentage reduction in overweight including obesity by income group (BMI 25kg/m2) (95% credible intervals)

	Overall	Male	Female
Income group 1	0.6% (0.4% to 0.8%)	0.4% (0.3% to 0.5%)	0.8% (0.5% to 1.1%)
Income group 2	0.6% (0.4% to 0.8%)	0.5% (0.3% to 0.6%)	0.8% (0.6% to 1.1%)
Income group 3	0.7% (0.5% to 1.0%)	0.6% (0.4% to 0.8%)	0.9% (0.6% to 1.2%)

Incomes groups are based on level of net household income and are grouped as follows: Group 1: <€19,999 per year; Group 2: €20,000-€39,999 per year; Group 3: >€40,000 per year. Estimates are based on a tax pass on rate of 90% and price elasticity of 0.9. Numbers of fewer overweight and obese are not presented because true underlying Irish population structure of each income group by age is not known.

Table 15: Percentage reduction in overweight including obesity for regular consumers and low consumers of carbonated SSDs (BMI ≥ 25kg/m2) (95% credible intervals)

	Overall	Male	Female
Low consumers	0.2% (0.2% to 0.3%)	0.2% (0.1% to 0.2%)	0.3% (0.2% to 0.4%)
Regular consumers	1.6% (1.1% to 2.1%)	1.3% (0.9% to 1.7%)	2.1% (1.4% to 2.7%)

A reduction in overweight including obesity prevalence is seen for low consumers of carbonated SSDs principally due to a reduction in consumption of non-carbonated SSDs. Estimates are based on a tax pass on rate of 90% and price elasticity of 0.9. Numbers of fewer obese and overweight are not presented because underlying Irish population structure by for each income group by age is not known.

Modelling: Sensitivity Analysis

The sensitivity analysis is undertaken on two of the assumptions (the tax pass on rate; and the price elasticity value). Taking a lower value for the tax pass on rate (80%) and the price elasticity (0.8) (equivalent to a 6.4% reduction in consumption for a 10% tax) the predicted reduction in obesity is 0.98% (4,840 people); and the predicted reduction in overweight, including obese, is 0.53% (9,210 people). Taking a higher value for the tax pass on rate (100%) and the price elasticity (1.0) (equivalent to a 10% reduction in consumption for a 10% tax) the predicted reduction in obesity is 1.53% (6,930 people); and the predicted reduction in overweight, including obese, is 1.01% (14,340 people). The corresponding point estimates (for 90% and 0.9) are 1.25% (6,170 people) and 0.67% (11,650 people). The point estimates here are based on self-reported height & weight, and are not adjusted for measured height & weight.

For women, the predicted range for the percentage reduction in obesity is 0.99% to 1.55% (2,290 to 3,580) and the percentage reduction in overweight, including obesity, varies from 0.65% to 1.01% (4,800 to 7,410 people). For men the predicted range for percentage reduction in obesity varies from 0.97% to 1.52% (2,560 to 3,990 people); and the reduction in overweight, including obesity, varies from 0.44% to 0.69% (4,410 to 6,930 people). The lower value is derived from 80% pass on and 0.8 price elasticity. The higher value is derived from 100% pass on and 1.0 price elasticity. The point estimates here are based on self-reported height & weight, and are not adjusted for measured height & weight.

Discussion

<u>Key findings</u>

The 10% tax on the price of SSDs is predicted to reduce the number of obese adults (defined as a body mass index (BMI) ≥30kg/m2) by around 10,000 (95% credible intervals: 7,000 to 13,000) and the number of adults who are overweight including obese (BMI≥25kg/m2) by 14,000 (10,000 to 18,000). This represents a reduction in the population who are obese of 1.25% and of the population who is overweight including obese of 0.67%[74].

The average reduction in calorie intake in the adult population of Ireland, as a result of the tax, is predicted to be 2.1 kcal per day, or 15 kcal per week; the predicted reduction is greater in the young (e.g. a mean of 32 kcal per person per week in those aged 18-24) and in regular drinkers of carbonated SSDs (a mean of 35 kcal per person per week).

The health impacts on men and women are similar with a predicted reduction in female obesity of 5,300 (1.26% of women who are obese) and male obesity of 4,600 (1.24% or men who are obese) cases. The reduction in obesity is predicted to be greater in regular consumers of SSDs (3.3 % reduction among regular consumers compared to a 0.5% reduction among low consumers). The impact of the tax (in terms of obesity reduction) is broadly similar across income groups[75.] Although obesity shows a gradient across income groups this is slight (a prevalence of 16.7% in those with the highest income compared with 13.5% in those with the lowest) and SSD consumption is relatively uniform across socio-economic groups.

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[74] This percentage reduction refers to the percentage change in the number of people in Ireland who are obese (or overweight & obese). It does not refer to the change in the percentage point change in obesity within Ireland, this would be 0.3%. This represents a decrease in prevalence from 23.0% to 22.7%. For obese & overweight, the percentage point reduction would be 0.4%, a reduction from 61% to 60.6%.

[75] The impact here refers to both the relative and absolute effects. A greater absolute effect should be seen in those with a lower income because of the higher absolute prevalence and similar relative changes. In practice this pattern was not clearly observed because the differences in absolute prevalence was slight between income groups.

Comparison with other studies: modelling results

Key studies estimating the effect of a SSD tax on mean body weight, calorie intake or consumption of SSD are shown in table 16. Many of these studies have come from the USA, where consumption of SSDs is much greater, and so any consequent decrease in calorie intake may also be expected to be larger. Most of these studies have modelled higher tax rates, typically 20%. Most have also modelled cross-price elasticity effects. It should also be noted that there is a range in estimates of the effect of such a tax in the US. Those studies that included purchases made away from home, as well as drinks purchased for consumption at home, found larger changes. Most studies (Lin, 2011; Dharmasena, 2011; Andreyeva, 2011) have taken a similar approach to our methods here, using price elasticity values to measure the consumption changes, from which calorie changes and weight changes are then derived. Some have used empirical data to directly relate price changes to calorie (Finkelstein, 2010) or weight changes (Schroeter, 2008).

Table 16: Summary of work modelling effects of taxes on SSDs

Study	Setting	Proposed tax	Change (per person)	Notes
Ng 2011	UK	10% tax	Consumption reduced by 53ml/week (equivalent to 3.1kcal/person/day)	Found limited substitution with "diet" or other drinks
Lin 2011	US	20% tax	Reduction of 34-47kcal/person/day	Consumption both at and away from home included
Andreyeva 2011	US	1 cent/ounce tax (~20% increase)	Reduction of 45-50kcal/person/day	Assumed no substitution with other drinks
Dharmasena 2011	US	20% tax	Reduction of 15kcal/person/day	Only considered consumption at home
Finkelstein 2010	US	20% tax	Reduction of 7kcal/person/day	Only considered consumption at home
Schroeter 2008	US	10% tax	Loss of 0.086 kg for an average man and 0.091 kg for an average woman	Unclear whether consumption both at and away from home included

Based on peer review articles from the Thow et al systematic review22 updated and combined with the Yale Rudd Centre study synopses (www.yaleruddcenter.org/resources/upload/docs/what/policy/SSBtaxes/SSBStudies_Taxes.pdf).

The Irish result (mean daily reduction of 2.1 kcal/person/day) is low compared to other studies. However, this can broadly be explained by differences in consumption of SSDs (US estimates: 136-197kcal/person/day; UK estimates:

76kcal/person/day; Ireland 26kcal/person/day) and the lower tax rate modelled in Ireland. The mean weight loss predicted by our model is equivalent to around 0.1kg/person and is similar to the 10% tax modelled by Schroeter (2008).

Comparison with other estimates of SSD consumption and obesity in Ireland

The IUNA (Irish Universities Nutrition Alliance) dataset (2011) is a second smaller representative study of the health of the Irish population. The study included measurements of the participant's height and weight, as well as a four-day food diary of dietary intake.

The estimates of SSD consumption reported in IUNA[76] are greater. The consumption of carbonated SSD as reported in the SLAN survey (an average of 45 ml/day/person) is less than the consumption of 'carbonated beverages (non-diet)' (an average of 82 g/day/person) as reported in the IUNA survey. Fruit juice consumption is reported to be higher in SLAN: an average of 82 ml/day/person compared with 50 g/day/person in IUNA. Diet drink consumption and squash/cordial consumption is similar in the two surveys. 'Low calorie or diet soft drink' consumption was reported to be 29 ml/day/person in SLAN compared with 'diet carbonated beverage' consumption of 24 g/day/person in IUNA. Non-carbonated SSD consumption was report to be 10 ml/day/person in SLAN compared with a consumption of 'squashes, cordials and fruit juice drinks' of 12 g/day/person in IUNA.

Food diaries, when done well, tend to be considered more accurate than food frequency questionnaires. The use of a more contemporaneous dataset (2011 for IUNA vs. 2007 for SLAN), the different definition/words used to describe SSDs (fizzy soft drinks in SLAN vs. carbonated beverages (non-diet) in IUNA), and the different age groups (16-64 years for IUNA vs. 18 years and above for SLAN) may explain some of the differences between the two surveys.

[76] IUNA figures are averages (mean) for the population aged 16-64 years; SLAN figures are averages for the adult population (aged 18 years and above).

Using the SLAN dataset in the model may result in underestimating the baseline consumption of SSDs, and the consequent reduction in consumption (measured in volume and calories) of SSDs. This will lead to a lower estimate of the effects of the tax on overweight and obesity, in comparison with the estimates from the IUNA dataset.

The estimates of obesity prevalence used for age and sex specific results (based on self-report) are less than those based on measured height and weight from IUNA and SLAN, the prevalence of measured obesity in IUNA being 23%, and SLAN being 23%. Given the consistency of agreement between these two surveys (using measured height and weight) taken at separate time points and the known unreliability of self-reported height and weight, a decision was made to adjust the estimates based on self-reported height and weight for the headline estimates produced in this report. Nonetheless the estimates who are obese or overweight or estimates of the number fewer who will be obese or overweight by sub-group which are based on self-reported data (both in terms of numbers and proportions of the total population) are likely to be under-estimates.

The Household Budget Survey (HBS) for Ireland also provides a measure of soft drinks purchasing. It is estimated that the average weekly expenditure is 4.14 Euros per family on soft drinks ("soft drinks not concentrated, not low-cal" and "soft drinks concentrated, not low cal") (estimate provided by Prof David Madden). However, this only includes such drinks consumed at home; it is anticipated that some fraction of money spent on meals out includes spending on SSDs, but it is not possible to determine how much. It is also unclear what volume (and calories) 4.14 euros would buy, as there is heterogeneity in volume per price. The survey does not include estimates of volume purchased.

Limitations

As with any piece of modelling work, a number of assumptions are made. These are set out in table 17. A key area of uncertainty is around substitution of SSDs with either food or other drinks. Cross-price effects are thought to be much more

context dependent than own price values and there is less data to describes these effects. Without elasticity data derived from econometric analyses on the Irish population we do not feel we have appropriate cross-price elasticities that can be used in modelling the substitution effects in Ireland. In not explicitly modelling cross-price effects, we are in effect modelling cross-price effects at zero.

The most likely substitution is from SSDs to other drinks; those specifically identified are soft drinks with artificial sweeteners and fruit juices. Substitution to drinks with artificial sweeteners (the closest substitute) would not significantly alter the impact on calorie reduction as these drinks contain no or minimal calories. Significant substitution with caloric drinks (e.g. fruit juice) would mitigate the effects on obesity. Significant substitution with non-caloric drinks (e.g. water or 'diet drinks') would not meaningful effect the estimates in this report.

The USA studies, which report empirical cross-price data, describe substitution of SSDs with fruit juice, milk and bottled water (Lin, 2011); and fruit juice, milk, tea, and coffee (Dharmasena, 2011). Both US studies suggest that diet drinks would decline as a result of a price rise on SSDs. The UK study suggests some small non-significant substitution with diet drinks (Ng, 2011) and no significant effect on fruit juice or milk consumption. The behavioural literature suggests that liquid calories are 'passively consumed' (i.e. individuals do not register or recognise the calories in SSDs, leading to over consumption; and that their addition or removal from the diet does not lead to compensatory adjustments in food calories consumed) (HIA Literature review). This may suggest that it is possible to reduce or remove SSD consumption from the diet without causing compensatory behaviour.

As with other authors (Lin, 2011; Dharmasena, 2011; Andreyeva, 2011; Ng, 2011) we have assumed that there is no substitution from soft drinks to food items. The behavioural literature (HIA Literature review) tends to support this, but we are not aware of explicit empirical elasticity data that supports this.

This work has focused on the health impacts in terms of obesity. Other health benefits, such as reductions in type II diabetes, are likely to result from reductions in obesity. Other health benefits (e.g. dental caries, diabetes, heart disease) are likely to be the result of reductions in SSD consumption per se. The work is applied to Ireland, and uses Irish specific data (in terms of beverage consumption, obesity distribution and prevalence) so caution should be applied in extrapolating to other settings. While the work has made estimates of effect sizes by age, sex, socio-economic status, body mass index, and consumption status, no allowance has been made for different behavioural responses by these groups. It has been hypothesised that certain groups (the young, and those on a lower income) might be expected to be more price sensitive, and show greater elasticity values than the rest of society (Brownell, 2010). Conversely others (older people and those on a higher income) may be less price sensitive. Credible intervals not confidence intervals have been calculated. No significance testing has taken place, so caution should be applied in making judgements about whether differences between groups are significant.

Table 17: Modelling a soft drinks tax in Ireland - assumptions used with the modelling exercise

Assumption	Modelled Value	Sensitivity Analysis	Author's confidence in the assumption	Comment
Pass on rate for tax	90%	Yes: modelled at 80% and 100%	Moderate	Pass on rates have been poorly studied. Emerging evidence from the French soft drinks tax shows variation in pass on rate (Letschner, 2012). A lower value will result in smaller effects; a higher value will result in larger effects.
Price Elasticity of demand	0.9 (based on literature)	Yes: modelled at 0.8 to 1.0	High	Fair agreement across international literature and experience from Ireland (Bahl, 2003)
Cross-price elasticity effects	Assumed to be zero	None	Low	Assumed to be zero as no data for Ireland identified. Likely substitutes appear to be diet drinks and fruit juice. Substitution to drinks containing calories (e.g. fruit juice) will mitigate the estimated impact on obesity to non-caloric will have

				minimal effect on the estimates. Substitution with confectionary has been hypothesised but has not described in the literature.
Time period during which changes in price and consumption persist	Changes are sustained	None	Moderate	Economic theory tends to assume that changes from prices are sustained. Other effects (e.g. from a rise in disposable income) over time may mitigate the initial change but the underlying effect remains
Reduction in purchasing of drinks leads to a reduction in consumption	Assume that every portion less of SSD purchased results in one less portion of SSD consumed	None	Moderate	Wastage of drinks is low (around 2.5% in the UK (WRAP, 2011))
Calorie density of sugar sweetened soft drinks	82kcal per portion of carbonated SSD drinks; and 47kcal per portion of non-carbonated SSD	None	High	Standard nutrition tables and techniques used in nutrition research; data taken from SLAN food composition table (appendix 1)
Physical Activity levels	Assumed to be unchanged	None	High	Unlikely that a small tax on SSD would cause physical activity to change
Effect of change on energy balance on weight	Equations drawn from Christiansen (2002)	Validity check with Hall (2008)	High	Validated Christiansen (2002) equations that agree well with other estimates
Distribution of change in calories/weight within the population	Modelled a log normal shift in the distribution of BMI for age and sex specific strata	None	High	This does not assume that everybody changes consumption (or weight by the average amount) within each age or sex strata. There can be considerable heterogeneity in individual responses but the change in population average is modelled. Shifts of different magnitude for the different age and sex groups have are modelled

Conclusions

A 10% tax on the price of sugar sweetened drinks in Ireland is predicted to reduce the number of obese adults by around 10,000 (95% credible intervals: 7,000 to 13,000) and the number of adults who are overweight, including obese, by 14,000 (10,000 to 18,000). This represents a reduction in obesity of 1.25% and in the overweight, including obesity, of 0.67%.

Appendix 1:

Table A1: Drinks composition database for SLAN 2007 – portion sizes and calorie density

Drink	Portion size (g)	Energy Density (kcal/ 100g)	Kilocalories per portion (kcal)
Tea	190	0	0
Coffee	190	0	0
Coffee ground	190	2	4
Cocoa/hot chocolate	200	76	152
Horlicks/ovaltine	200	99	198
Wine	125	71	89
Beer/lager	287	30	86
Port/sherry	50	116	58
Spirits/gin/whiskey	35	222	78
Low calorie diet drinks	200	1	2
Fizzy soft drinks	200	41	82
Pure fruit juice	160	36	58
Fruit squash	50	93	47

Appendix 2: Further notes on weight loss

Comparison of weight loss predicted by Hall (2011) vs. Christiansen (2008)

The currently favoured model for estimating the effects of energy balance on weight is the Hall model (http://bwsimulator.niddk.nih.gov/; Lancet, 2011). The two models (Hall, 2011 and Christiansen, 2002) compare similarly (table A1 and A2) over the range of calorie changes predicted in the model (around 2-5 kcal/person/day).

For larger calorie changes (a reduction of 135kcal per day – equivalent to drinking one less 'carbonated SSD' a day) differences in the model are noticeable, but slight (both predict around 6 to 7kg of weight loss depending on baseline BMI and sex). While Hall (2011) tends to be more conservative than Christiansen (2002), this is not always the case. Towards the high end of body mass index (e.g. BMI of 41 in table A1 and A2) Hall tends to overestimate weight loss compared to Christiansen. On the critical border between obesity and overweight, Christiansen tends to slightly overestimate, but the differences are very small. At lower body mass indices the overestimation of Christiansen is more apparent.

While Christiansen (2002) is silent on the time period over which the changes would occur, simply stating the new steady weight. Hall (2011) gives some indication over the time period over which weight loss occurs, and this will be dependent on the calorie reduction that occurs. Most weight loss will occur over the first year. A new steady state weight is achieved within 2-3 years, but weight loss may continue for up to 8-10 years.

The 'rule of thumb' predicts that over a year an individual would cut 766 calories from their diet (365 days x 2.1 calories/day), and this would result in weight loss of 0.10kg. Over half a year these figures are 383 calories and 0.05kg. Over two years these figures are 1533 calories and 0.20kg.

Average weight loss in a population

The reductions in weight loss from the predicted calorie changes appear small. The average calorie reduction (across the whole population) of 2 calories/day equates to weight loss of around 0.1kg. This is greater when only considering the regular consumers of SSDs (5 calories per day and up to 0.3kg) or looking at young adults. It is often questioned whether small changes (such as these) make a difference.

Small changes spread across the whole population may often have bigger effects on the population's health, than strategies just targeted at individuals who are at particularly high risk (Rose, 1992). This occurs when a risk factor (or disease) in this case obesity is spread across a large proportion of the population. Simply put small changes to many sum to a large change for the whole population.

An alternative means to understand the effect of such a tax would be to acknowledge that the tax will affect individuals differently. Some individuals will not change their behaviour, where as some will change their behaviour. In some individuals the tax (and associated negative publicity towards SSDs) may be the incentive to change from a daily 330ml SSD (typically 135 calories) to consuming to drinking water (135 calorie daily reduction). An average change of 2.1kcal would be equivalent to one person in every 64 people giving one portion of SSDs a day (or one person in 32 drinking giving up one portion of carbonated SSD every other day). Such a change in energy balance (if uncompensated) would result in weight loss of 6-7kg for an adult who is obese, and a reduction in BMI of 2-3 kg/m2. The figures for a person drinking one less portion of carbonated SSDs every other day would be around 3.5kg (Table A1 and A2). Similar weight gain may also be prevented in a young adult who chooses not to start regularly consuming SSDs in response to the taxation.

Table A2: A comparison of the estimated weight loss predicted for a given daily calorie change calculated by different methods for women

	Weight Loss in kg (BMI reduction in kg/m2)	
	Hall	Christiansen
30 year old female: BMI of 31 2 kcal/day reduction	0.1kg 0.04kg/m2	0.11kg 0.04kg/m2
30 year old female: BMI of 26 2 kcal/day reduction	0.1kg 0.04kg/m2	0.11kg 0.04kg/m2
30 year old female: BMI of 41 2 kcal/day reduction	0.1kg 0.04kg/m2	0.11kg 0.04kg/m2
30 year old female: BMI of 31 5 kcal/day reduction	0.2kg 0.09kg/m2	0.27kg 0.10kg/m2
30 year old female: BMI of 31 78 kcal/day reduction	3.6kg 1.3kg/m2	4.23kg 1.59kg/m2
30 year old female: BMI of 31 135 kcal/day reduction	6.4kg 2.4kg/m2	7.31kg 2.75kg/m2
30 year old female: BMI of 41 135 kcal/day reduction	7.6kg 2.8kg/m2	7.31kg 2.75kg/m2

A 30 year old female with a BMI of 31 kg/m2 is assumed to have a height of 1.63m and a weight of 82.4kg; A 30 year old female of BMI is 26 is assumed to have a height of 1.63m and a weight of 69.1kg; A 30 year old female of BMI is 41 is assumed to have a height of 1.63m and a weight of 108.9kg

Table A3: A comparison of the estimated weight loss predicted for a given daily calorie change calculated by different methods for men

	Weight Loss in kg (BMI reduction in kg/m2)	
	Hall	Christiansen
30 year old male: BMI of 31 2kcal/day reduction	0.1kg 0.03kg/m2	0.09kg 0.03kg/m2
30 year old male: BMI of 26 2 kcal/day reduction	0.1kg 0.03kg/m2	0.09kg 0.03kg/m2
30 year old male: BMI of 41 2 kcal/day reduction	0.1kg 0.03kg/m2	0.09kg 0.03kg/m2
30 year old male: BMI of 31 5 kcal/day reduction	0.2kg 0.07kg/m2	0.23kg 0.07kg/m2
30 year old male: BMI of 31 78 kcal/day reduction	3.5kg 1.1kg/m2	3.61kg 1.15kg/m2
30 year old male: BMI of 31 135 kcal/day reduction	6.1kg 1.9kg/m2	6.25kg 2.00kg/m2
30 year old female: BMI of 41 135 kcal/day reduction	7.2kg 2.3kg/m2	6.25kg 2.00kg/m2

A 30 year old male is assumed to have a height of 1.77m and a weight of 97.1kg; A 30 year old male of BMI is 26 is assumed to have a height of 1.77m and a weight of 81.5kg; A 30 year old male of BMI is 41 is assumed to have a height of 1.77m and a weight of 128.5kg

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Appendix 9: Ipsos MRBI Polling Information

In parallel to the HIA process, the Health Research Board on behalf of the Department of Health commissioned Ipsos MRBI to measure public attitudes and behaviours towards SSDs and the proposed tax. Ipsos MRBI administered the face-to-face questionnaire to a national quota sample of 1,020 adults age 18 and over, representative of the 3.4 million adults in Ireland, in May 2012. This covered 100 sampling points throughout all counties in the Republic of Ireland.

Sample Profile (n=1020)

Classification		Number of Respondents	Unweighted Sample %	Weighted Sample %	Census 2011
Age	18-24 years	126	12	12	12
	25-34 years	225	22	22	22
	35-49 years	294	29	29	29
	50-64 years	220	22	21	21
	65 years & over	155	15	16	16
Gender	Male	491	48	49	49
	Female	529	52	51	51
Region	Dublin	279	27	28	28
	Rest of Leinster	261	26	27	27
	Munster	281	28	27	27
	Conn/ Ulster	199	20	18	18

The following are the questions asked in this questionnaire:

- In the past 12 months, have you purchased any sugar sweetened drinks? By sugar sweetened drinks I mean soft drinks like fizzy drinks and cordials, energy drinks and fruit juices with added sugar.
- To what extent do you agree or disagree with the following:
    - If the price of sugar sweetened drinks was to increase by 10%, I would buy them less often.
    - If the price of sugar sweetened drinks was higher than diet drinks I would switch to diet drinks.
    - If I drank less sugar sweetened drinks, I would drink water instead.
    - Irish children and young people consume too many drinks sweetened with sugar.
    - Sugar sweetened drinks contribute significantly to obesity among children and young people in Ireland.

These are the results of the questionnaire outlining public consumption habits and opinions as well as anticipated responses to changes in SSDs costs:

- 73% of the sample had purchased SSDs in the past year; purchasing was more common among young age groups and women.
- 44% of purchasers said they would buy SSDs less frequently if the price increased by 10%, but 34% said it would not change their purchasing behaviour. Women are more likely to respond to a 10% price increase than men.
- 40% of purchasers stated they would switch to diet drinks if they were cheaper than SSDs while 38% said they would not.
- 60% of purchasers of SSDs said they would drink water if they drank less SSDs.
- 91% think that children and young people in Ireland drink too many SSDs. This opinion is consistent across gender and age categories.
- 87% believe that SSDs significantly contribute to obesity among children and young people in Ireland.

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October 2012