Reviews of Scientific Evidence and Policies on Nutrition and Physical Activity

Objective B2: Consumption, energy intake and impact of fruit juices and of artificially and sugar sweetened beverages

Written by ICF Consulting Services Ltd

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European Commission

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EUROPEAN COMMISSION

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Objective B2: Consumption, energy intake and impact of fruit juices and of artificially and sugar sweetened beverages

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Preface

About this project

Overweight, obesity and their related diseases represent a leading cause of morbidity and mortality, and pose a major challenge for the sustainability of healthcare systems of EU Member States. The growing prevalence of overweight and obesity among all age groups across Europe constitutes a serious concern for policy makers. Tackling this issue requires a comprehensive response that reflects the multifactorial and complex nature of obesity and overweight. One particularly important area of focus has been on the development of preventative strategies which include nutritional and physical activity interventions.

The European Commission Directorate General for Health and Food Safety (DG SANTE) recognises the significant challenges policy makers face in developing effective and efficient policy interventions relating to diet and physical activity. One such challenge includes the complexity and breadth of the evidence base. By providing independent, accurate summaries of recent and relevant information and statistics on determinants of diet and physical activity and their impact on health, this project aims to support policy makers to continue to develop policy instruments which enable people to make healthier lifestyle choices. In particular, this project aims to support the development of healthier behaviours in vulnerable and/or at-risk subpopulations (including children, pregnant and lactating women, and older adults) and low socio-economic status groups (including low income and education).

About this series

This evidence review is one of eight reviews relating to different determinants of diet and physical activity.

Seven of the reviews are of the scientific evidence and policies in the following areas:

- Knowledge, attitudes and behaviours contributing to positive energy balance (objective area A1);
- Dietary and physical activity patterns in Europe (objective area B1);
- Consumption of fruit juices, artificially and sugar-sweetened beverages and its impact on weight status and health (objective area B2);
- Consumption of high-fructose syrup and its impact on weight status and health (objective area B3);
- Relationship between weight status and physical activity with school and work performance outcomes (objective area C);
- Early warning indicators of obesity and physical inactivity trends (objective area D);
- Nutrition and physical activity guidelines for specific population groups (objective area E).

Building on these seven reviews, the final review (objective area A2) examines specifically the evidence for effective and efficient policies and interventions in terms of promoting, supporting and improving nutritional and physical activity behaviours at both individual and population level.

All reviews, and their summaries, are available on the DG SANTE webpage here.

Approach and purpose

The reviews have been designed to provide policymakers with summaries of recent and relevant evidence in these key areas of interest. Given the broad scope of each of the reviews, it should be stressed that they are not intended to be rigorous systematic reviews of all literature published in this field. Rather, they are intended as pragmatic reviews combining a comprehensive search methodology with expert academic input,

facilitated through workshops, to provide a practical and accurate summary of key issues and tackling broad lines of enquiry, with the greater aim of supporting the development and improvement of policies in this area. Each of the project's eight methodologies and analyses was reviewed by DG SANTE and academic experts in these topics.

While the methods to conduct this comprehensive literature review are systematic, it is *not* a systematic review. This review does not systematically analyse literature to identify *all* relevant published data and/or appraise its quality. Methods to conduct the literature review consisted of five steps: (1) refining the research questions, (2) developing a search approach and databases, (3) conducting literature searches, (4) screening articles for inclusion; and (5) abstracting and synthesising relevant data.

To minimise bias, the literature search approach included identification of a priori search parameters (also considered first level inclusion and exclusion criteria), agreed with DG SANTE, to guide searches and inform screening and selection processes for data inclusion. Due to the immense number of literature search results at step 3, the application of quite limiting exclusion criteria at step 4 was deemed necessary. This may however have resulted in not screening all potentially relevant literature. All relevant articles that were found appropriate for inclusion were reviewed for relevance to each objective area, and the scope of the specific research questions. Furthermore, the inclusion of different types of scientific evidence (from systematic reviews and peer-reviewed original articles down to BSc theses) and the presentation of this scientific evidence next to grey literature information presented a challenge in terms of maintaining an understanding of the quality and weight of the evidence. The authors addressed this to some extent by structuring the document in such a way that peer-reviewed and grey literature are clearly identified. The full methodology and steps taken for each review is included in Annex of this document.

DG SANTE and the Joint Research Centre (JRC) provided input on all stages of the project and comments on the literature reviews. Expert workshops were organised to discuss findings, highlight additional relevant sources to fill gaps and improve the series of reviews. Experts were carefully selected from academic and policy-making fields, based on expertise of the specific topics addressed.

The methodology used across all eight reviews remained consistent, and within each review a detailed summary of the approach is provided, along with a full bibliography for further reading.

Glossary

The following definitions are common definitions that are used across all eight objective areas. Where a study uses a different definition, this will be highlighted on an individual basis in the review.

Table 1. Definitions of terms used across the reviews

Term	Definition	Source
Adult obesity	An abnormal or excessive fat accumulation that presents a risk to health, with a BMI of 30 or more.	World Health Organisation (WHO) (http://www.who.int/topics/obesity/en/)
Adult overweight	An abnormal or excessive fat accumulation that presents a risk to health, with a BMI equal to or more than 25.	WHO (http://www.who.int/topics/obesity/en/)
Alcopops	Pre-mixed beverages containing a spirit, wine or malt combined with a non-alcoholic drink.	1. Anderson, P., Suhrcke, M. and Brookes, C. (2012) An overview of the market for alcohol beverages of potentially particular appeal to minors. London: HAPI.
Artificially sweetened beverages (ASBs)	Beverages sweetened with low-calorie or zero-calories sweeteners such as sucralose, aspartame, saccharin, stevia or sugar alcohols.	ICF definition based on all literature identified in objective area B2 literature review
Body Mass Index	A person's weight (in kilograms) divided by the square of his or her height (in metres).	WHO (http://apps.who.int/bmi/index.jsp?introPage=intro_3.html)
Child/adolescent obesity	• There are different systems available to measure child or adolescent obesity for different ages. • Children under 5 obesity is weight-for-height greater than 3 standard deviations above WHO Child Growth Standards median;	WHO http://www.who.int/mediacentre/factsheets/fs311/en/ (Other definitions are available for different national and international systems).

Term	Definition	Source
	• Children aged 5-19 overweight is BMI-for-age greater than 2 standard deviation above the WHO Growth Reference median.	
Child/adolescent overweight	There are different systems available to measure child or adolescent overweight for different ages. • Children under 5 overweight is weight-for-height greater than 2 standard deviations above WHO Child Growth Standards median; • Children aged 5-19 overweight is BMI-for-age greater than 1 standard deviation above the WHO Growth Reference median.	WHO http://www.who.int/mediacentre/factsheets/fs311/en/ (Other definitions are available for different national and international systems).
Exercise	Exercise, is a subcategory of physical activity that is planned, structured, repetitive, and purposeful in the sense that the improvement or maintenance of one or more components of physical fitness is the objective.	WHO (http://www.who.int/dietphysicalactivity/pa/en/)
Insufficient physical activity	Physical activity that does not meet WHO recommended levels of at least 60 minutes a day of moderate-vigorous activity for children and adolescents and at least 150 minutes of moderate-intensity aerobic physical activity throughout the week for adults.	WHO http://www.who.int/mediacentre/factsheets/fs385/en/

Term	Definition	Source
Physical activity	Any bodily movement produced by skeletal muscles that requires energy expenditure.	WHO (http://www.who.int/topics/physical_activity/en/)
Physical inactivity	A lack of physical activity	WHO (http://www.who.int/dietphysicalactivity/pa/en/)
Sedentary behaviour	Any waking behaviour characterized by an energy expenditure ≤1.5 metabolic equivalents (METs) while in a sitting or reclining posture.	Tremblay, M. S., et al. (2017). Sedentary Behavior Research Network (SBRN) – Terminology Consensus Project process and outcome. *The International Journal of Behavioral Nutrition and Physical Activity*, *14*, 75. http://doi.org/10.1186/s12966-017-0525-8
Sugar sweetened beverages (SSBs)	Any beverage with added sugars. This includes soft drinks, soda, fruit drinks, punch, sports drinks, sweetened tea and coffee drinks, energy drinks and sweetened milk. These beverages may be sweetened with added sugars such as sucrose (table sugar) or high fructose corn syrup, which is what distinguishes them from 100% fruit juice and beverages with non-caloric sweeteners (e.g., aspartame, saccharin or sucralose).	US Department of Agriculture. 2010. *US Department of Health and Human Services. Dietary guidelines for Americans, 2010.* 7th edition, Washington (DC): US Government Printing Office

Objective B2: Consumption, energy intake and impact of fruit juices and of artificially and sugar sweetened beverages

This comprehensive review presents the findings from peer literature and grey literature reviews on the consumption, energy intake, and impact of fruit juices and of artificially and sugar sweetened beverages (including sweetened alcoholic beverages) on overweight, obesity, and health (including alcohol-related harm).

The review is structured by the following sections:

- Introduction, describing the relevance of the topic and defining the terminology used, the scope of the review, and the principal research questions;
- Methodology, describing how both reviews were undertaken and the relevant findings extracted;
- Findings from the peer-reviewed and grey literature, presented according to each research question; and
- Conclusions drawn from the assessment of the scientific evidence, along with any research gaps highlighted.

1 Introduction

Sugar sweetened beverages, fruit juices, low-calorie and artificially sweetened beverages, and sweetened alcoholic beverages contain high volumes of sugar, calories, and/or artificial ingredients that pose health risks to consumers. As such, consumption of these beverages is a public health concern, particularly in light of high rates of overweight and obesity. This review examines the consumption and health impacts of these beverages, as defined below.

Sugar Sweetened Beverages (SSBs)

SSBs are commonly defined as any beverage with added sugars (USDA 2010). SSBs include soft drinks, soda, fruit drinks, punch, sports drinks, sweetened tea and coffee drinks, energy drinks and sweetened milk (each defined in the text box to the right).[1] SSBs may be sweetened with added sugars such as sucrose (table sugar) or high fructose corn syrup. On average, a 330g serving of regular soda contains 31.2 grams of sugar (USDA 2015), however sugar content can vary greatly by product and by country of purchase (Action on Sugar 2015).

Sugar Sweetened Beverages (SSBs)

Soft drinks/Soda: non-alcoholic flavored, carbonated or non-carbonated beverages

Fruit drinks or punch: Sweetened beverage with diluted fruit juice/<100% fruit juice or fruit nectar with added sugar

Sports drinks: Beverages designed to rehydrate and replenish electrolytes, sugar, and other nutrients

Sweetened teas and coffee drinks: Teas and coffee drinks with caloric sweeteners

Energy drinks: Beverages with high amounts of caffeine, sugar and other ingredients such as vitamins, amino acids and herbal supplements

Sweetened milks or milk alternatives: Beverages with sweetened powder or syrup and milk

Fruit Juices

100% fruit juices (fruit juice)[2] also contains a high volume of sugar (32 grams of sugar per 330ml serving on average (USDA 2015), however they are not categorised as a SSB because fruit juice contains naturally occurring ingredients with no *added* sugars. Although fruit juices do have nutritional benefits, there are concerns that the high sugar content of fruit juices may contribute to overall caloric intake and potentially to weight gain (as discussed in section 3.1.4.1 below).

Low-Calorie Sweetened (LCS) and Artificially Sweetened Beverages (ASBs)

A variety of beverages on the market, including those listed under SSBs, can be sweetened with low-calorie or zero-calorie sweeteners (e.g. aspartame, saccharin, or sucralose) as alternatives to sugar. These beverages, often referred to as low calorie sweetened (LCS) beverages or artificially sweetened beverages (ASBs)[3], have great consumer appeal as they contribute zero or few calories when consumed compared with SSBs and fruit juice. However, as discussed in section 3.1.4.3 below, there are concerns about the behavioural and health consequences associated with consumption of artificial sweeteners, such as increased risk of obesity and greater desire for sweet tasting foods.

[1] Definitions provided reflect a general census of how various SSBs are usually described in peer reviewed literature. For the purpose of this review, references to these terms reflect these definitions, unless otherwise noted.

[2] For the purpose of this review, the term “fruit juice” refers only to 100% fruit juice and is not included in the definition of SSBs; alternatively, fruit drinks or fruit punch refers to beverages containing <100% fruit juice or fruit nectar with added sugar and are included in the definition of SSBs.

[3] For the purpose of this review, non-nutritive, low-calorie and zero-calorie sweeteners are all treated as a single category and abbreviated as “LCS beverages” and exclude (apart from sucrose and high fructose corn syrup) other sweeteners containing sucrose or fructose such as honey or agave.

Alcopops
Alcopops[4] are pre-mixed beverages containing a spirit, wine or malt combined with a non-alcoholic drink (Anderson, Suhrcke and Brookes, 2012; Rabinovich et al, 2009; and Anderson & Baumberg, 2006). Given their pre-mixed nature, they are often referred to as ready-to-drinks (RTDs). The sugar and calorie content of these beverages is concerning, but beyond this, the appeal of the sweet taste to underage youth and potential for alcohol-related harm are additional causes for concern, as discussed in section 3.1.6 below.

1.1 Scope of the review

Drawing on a search of the peer reviewed and grey literatures, the purpose of this review is to determine current consumption patterns of SSBs, 100% fruit juices, LCS beverages, and alcopops, and the adverse health consequences of their consumption with regard to overweight and obesity, alcohol-related harm and the development of sweet taste preferences. In general, findings in this review focus on European data and trends, but data from other countries are included where available and where useful for comparative purposes.

Use, consumption, and health impact of high fructose corn syrup (HFCS) is beyond the scope of this objective and is covered separately under objective B3. In addition, discussion of existing sweetened beverage policies and their effect on sweetened beverage consumption is presented in the literature review for objective A2.

1.2 Research questions for this review

Findings from the review are structured around the following research questions provided by DG SANTE[5]:

- Who consumes SSBs, how much do they consume and what are the drivers behind such choices?
- Who consumes fruit juices, how much do they consume and what are the drivers behind such choices?
- Who consumes LCS beverages, how much do they consume and what are the drivers behind such choices?
- What are the consequences of such consumption on overweight and obesity?
- Who consumes sweetened alcoholic beverages (artificially or sugar-sweetened), namely alcopops and sweetened spirit drinks that are pre-mixed, how much do they consume and what are the drivers behind such choices?
- What are the consequences of such consumption on alcohol-related harm?
- What is the role played by artificial sweeteners in general and by LCS beverages in particular in developing a preference for the sugary taste and what behavioural and health consequences could there be?

The findings from the eighth research question (mentioned below) are included in Objective A2, as an overarching objective area report on existing policies in the broader thematic area of nutrition and physical activity:

- What policies are more effective and efficient in this area (information, advertising, taxation, reformulation, regulations, partnerships, etc.)?

[4] For the purpose of this review, all pre-mixed sweetened alcoholic beverages, including sugar and/or low-calorie sweetened, will be categorised under the term alcopops.

[5] Questions one, two, three and five were originally a single question but have been separated in this review to allow for a more comprehensive analysis.

2 Methodology

Peer reviewed literature and grey literature were both analysed to create the findings of this review. The review is mainly based on peer reviewed literature, and as such has been discussed first, followed by grey literature evidence which has been used to support peer reviewed evidence, fill any evidence gaps and/or further explain data or trends.

There is a summary box at the beginning of each sub-section which brings together the findings from the grey and peer literature reviews, highlighting any similarities and/or gaps in the evidence base.

For each set of literature, specific search terms, inclusion and exclusion criteria, and quality checks were carried out. The research questions and search terms were confirmed with DG SANTE at the start of the process.

After the initial searching and extraction of literature, expert workshops (with experts from relevant academic and policy-making fields) were conducted to discuss findings, highlight additional relevant sources to fill gaps and improve the series of reviews.

2.1 Peer-Reviewed Literature method

To search for and extract the most relevant peer reviewed literature the following steps were taken: refining the research questions; developing a search approach and databases; conducting literature searches; screening articles for inclusion; and abstracting and synthesizing relevant data.

A total of 9,532 search hits of peer reviewed literature were initially retrieved using selected search terms per research question (9,024 original research articles and 508 systematic reviews). 5,504 duplicates were found and removed from the search hits resulting in 4,208 unique search hits for B2. From the 4,208 articles, the team screened 200 of the most relevant and recent titles and abstracts for each research question. Where there was a lack of relevant literature for a research question, more than 200 articles were screened. For B2, 1,000 original research articles were screened (based on five original research questions). From the 1,000 most recent titles and abstracts screened, 75 were deemed of potential relevance and reviewed as full texts. From the 75 deemed relevant and reviewed as full texts, 41 publications were selected for inclusion in the final review. The full peer reviewed searching and extraction methodology is outlined in Annex 1.

After an initial reading by DG SANTE, the University of Birmingham and the expert working group, 19 additional references were added to the final review, bringing the total number of peer references to 60.

2.2 Grey Literature method

To search for and extract the most relevant grey literature, the following steps were taken: searching for publications using set keywords and databases; screening of search results and exclusion of less relevant literature; and, extraction and review of remaining documents. The grey literature search process was a more fluid and dynamic process compared to the peer reviewed method, where hand searching was also utilised to find the most relevant sources.

Search hits of grey literature were initially retrieved using selected search terms and filtered on the basis of key search terms in the title and relevance of the title to the review. 167 articles identified as relevant were saved to the library. A total of 87 results were excluded based on the inclusion/exclusion criteria, quality of evidence and relevance to the research questions. From the 80 deemed relevant and reviewed as full texts, 40 publications were selected for inclusion, in this final review. The full grey literature searching and extraction methodology is outlined in Annex 4.

After an initial reading by DG SANTE, the University of Birmingham and the expert working group, nine additional references were added to the final review, bringing the total number of grey literature references to 49.

3 Findings and discussion

Findings from the peer reviewed and grey literature searches are presented by research question below. As highlighted in section 1, where a specific definition varies from the definitions provided in the introduction, it has been clearly reported in the text below.

3.1 Research question 1: Who consumes SSBs, how much do they consume and what are the drivers behind such choices?

Summary

- SSB consumption is highest among men and among children and adolescents, with evidence to suggest that very young children are now consuming SSBs.
- The relationship between SES and SSB consumption is complex: educational status appears to be an important dimension of SES in predicting SSB consumption. Within high income countries, there is evidence that low SES is associated with high SSB consumption.
- Globally, there is nearly a tenfold difference between highest and lowest regional SSB intake levels. European regions report relatively low levels of SSB consumption compared to the rest of the world with evidence to suggest a general decline in SSB purchases across Europe since 2010. However, within Europe, there are large variations between MS. Western Europe reported the highest levels of overall consumption and at MS level, the literature identified the Netherlands (adults and children) and Belgium (adults) as the top SSB consumers.
- Among children, TV viewing/screen time, snack consumption, living near a fast food/convenience store and various parental factors including parental SES, age, SSB consumption, children attending out-of-home care, formula milk feeding and early introduction of solids were identified as drivers for SSB consumption. Early childhood SSB consumption was also linked with higher consumption in later childhood.
- Among adults, consumption of SSBs during childhood, obesity, stress, seasonality, price discounting and marketing and advertising were identified as key drivers.

The review on consumption of SSBs includes longitudinal and cross-sectional cohort studies across Europe, the United States, and Australia. It is important to note that different terminology was used in the studies (soda, soft drinks, SSBs, sweetened beverages, sweetened fruit drinks) but similar definitions were used. To simplify the presentation of literature review findings, the term SSB is used to refer to any alternative terms used in the literature included in this review. In the grey literature, where definitions of soft drinks were not provided, on the basis of the article subject and content, it was assumed that they were referring to SSBs.

3.1.1.1 Who consumes SSBs?

Despite some discrepancies between countries and studies, the following general SSB consumption patterns were identified:

- **Men consume more SSBs than women.** In 2010, SSB consumption globally was highest in men aged 20-39 (1.7 8 oz servings/day) and lowest in women aged 60 and over (0.53 8 oz servings/day) (Singh, 2015). These data are based on 62 surveys (n=612,100) representing 51 countries of varying income levels.

At country level, Heuer et al. (2015), in a nationally representative sample of 15,371 children and adults aged 14-80, found that on average, German men consume 2.5 times more SSBs than German women (229 g/day vs. 88 g/day[6]). Pooled data from an Australian nutrition monitoring survey (N=2,832 adults from Western Australia and 10,764 adults from Southern Australia aged 18 to 64) also demonstrated that males were more likely to consume SSBs than females (Pollard et al., 2016) and, in Greece, Malisova et al. (2015) found that Greek men consume more energy from SSBs than women (N=984).

A similar gender divide was identified in studies focussing on children, although the pattern varied by age and MS. Bjelland et al. 2013 found that Norwegian girls consumed SSBs less frequently at 18 months of age than boys (N=9025). However, this gender difference in SSB consumption was not present at 36 months and 7 years of age. The authors also noted a significant increase in the amount of SSBs consumed by both girls and boys from 18 months to 7 years old.

The grey literature identified a similar gender split among young children. Results from the 2014 HBSC study (Inchley et al. 2016)[7], which used self-reported data from 11-15 year olds across Europe and North America, showed that boys generally reported higher consumption of SSBs than girls. Boys reported a greater daily consumption across all age groups, except for 11 year olds in Ireland and 13 year olds in Israel, and, for each age group, gender differences were significant in more than half of countries and regions. At MS level, research in Germany (Mensink et al. 2007)[8] shows that more boys (25%) than girls (20%) consume soft drinks (including cola, lemonade and ice tea) on a daily basis and the daily consumption of soft drinks increases with age (while the daily consumption of juice decreases). Similar results were also found in Italy (Cavallo et al. 2016)[9] and Poland (Dzielska et al. 2015).

- **Young adults and adolescents consume more SSBs than older adults.** Heuer et al. (2015) found that adolescents (aged 14-18 years) and young adults (aged 19-34 years) consumed more SSBs than older participants (aged 35-80). Similarly, Singh et al. (2015) found that SSB consumption was highest in adults under age 40 and lowest for adults 60 and older. Grey literature also found that SSB consumption is high among younger individuals, with most studies focussing on very young children and adolescents. HBSC data from 2014 (Inchley et al. 2016) reported that the intake of SSBs among adolescents is a matter of concern and is higher than in any other age groups[10]. Furthermore, the study showed that in 23 countries and regions for boys and 16 regions for girls, the % of individuals who consume SSBs daily increased with adolescent's age. At individual country level, Tedstone et al. (2015) reported that the consumption of sugar and sugar-sweetened drinks is particularly high in school age children.

[6] Equivalent to 1.01 8oz servings per day for men and 0.39 8oz servings per day for women.

[7] The HBSC study is a 30 year cross-national study looking at 11, 13 and 15 year old boys' and girls' wellbeing, health behaviour and social context conducted every four years in 45 countries and regions across Europe and North America.

[8] The research uses a food frequency questionnaire to assess food frequency and portion size. Two identical questionnaires were distributed, one aimed at parents of 1-10 year-olds and the other directly at 11- 17 year-olds. The results include data on 7,186 boys and 6,919 girls aged 3-17.

[9] Cavallo et al. (2016) present the results of a survey conducted in 2014 throughout all Italian Regions, on 11, 13 and 15 year-old students attending public schools. Target classes were 1st and 3rd grades of junior high school and 2nd grade of high school. Around 65,000 questionnaires were collected.

[10] The report did not provide any comparative figures in the text to support this statement, although it referenced a peer reviewed article.

- **Very young children are consuming SSBs.** Grey literature reported evidence of SSB consumption among very young children. The Polish Expert group on intake of drinking water and other beverages by infants, children and youth, using research findings from Poland, the Netherlands, the UK, Germany, France, Austria and Switzerland (Woś et al. 2010) reported high SSB consumption among children as young as 1 year old , and Sjolin's (2006) review of the literature reported that 20% of the toddlers in the US consume soft drinks with an average soft drink consumption among these very young consumers of 7 ounces (approximately 207 ml) a day (Jacobson 2005, in Sjolin 2006). The high consumption observed in very young children is a relatively recent trend in Europe and the US, only emerging since the new millennium (Sjolin 2006). As further discussed in section 3.1.1.3 below, it may have broader implications for consumption of SSBs in later life.
- **SES affects SSB consumption, however the relationship is complex.**
  - **SSB consumption is highest in middle income countries and lowest in low and high income countries.** The link between SES and SSB consumption varies depending on overall country wealth. Across the world, Singh et al. (2015) found that SSB consumption was highest in upper-middle and lower-middle income countries (1.22 8 oz servings/day and 0.95 8oz servings/day, respectively). SSB intake was found to be lower in high and low income countries (0.71 8 oz servings/day and 0.56 8 oz servings/day, respectively)[11].
  - **Country income may be linked to different patterns of SSB consumption across social classes within a country: in high income countries, lower SES individuals are more likely to consume SSBs.** Findings from the 2014 HBSC study (Inchley et al. 2016) showed that in higher income countries (Canada, Spain, Germany, Hungary, Scotland, Belgium (French) and Belgium (Flemish)), boys were significantly more likely to consume soft drinks if they were from non-affluent families, while in middle to lower income countries (Albania, Romania, Republic of Moldova, Ukraine and Estonia), they were significantly more likely to consume soft drinks if they came from affluent families. For girls, a significant relationship between affluence and soft drink consumption was found in 19 countries, with consumption being higher among children from non-affluent families.

    In line with HBSC findings above, peer review studies in high income EU MS found evidence that SES is inversely related to SSB consumption for both adults and children. Heuer et al. (2015) found that, in Germany, both males and females with low socio-economic status consumed more SSBs than individuals of higher socio-economic status (N=15,371). A study in the Netherlands (Bjelland et al., 2013) found that at 18 months of age (N=9025), children of mothers with low educational status consumed SSBs more often compared to children of mothers of higher educational status.

    Grey literature reported similar findings among school-age children in Texas (Loring & Robertson 2014) while Sjolin's (2006) briefing for the European Parliament using peer-reviewed literature, concluded more generally that poor children are significantly more likely to receive more calories from soft drinks than wealthy children. At Member state level, findings of higher SSB consumption among lower SES households compared to middle income households were identified in Spain (Cerdeño 2014). However, Cerdeño (2014) did conclude that individuals from high/middle class households also consume more soft drinks than middle class households. In Italy, children from lower-educated families were also found to consume more sweetened beverages (the

[11] Country income levels were derived from the World Bank Atlas method.

study does not distinguish between sugar-sweetened and artificially sweetened beverages) than those from families where parents have a university degree (Nardone et al. 2016).

- **There is also tentative evidence to suggest that high levels of SSB consumption in children of low SES becomes more pronounced over time**, which could have implications for later life SSB consumption. In a longitudinal study[12] of Swedish school children (N=3,053), Moreaus et al. (2015) found that 7-9 year olds' consumption of SSB 4-7 days a week more than doubled over a two-year time period among children with low Socio Economic Position (SEP)[13] while remaining stable in children with high SEP.
- **Income alone may not be a strong predictor of SSB consumption patterns: educational status is an important dimension of SES.** A cross-sectional study (Fismen et al., 2016) of Danish, Finnish, Norwegian, and Swedish adolescents (N=6,000) aged 15 conducted in 2001/2002, 2005/2006, and 2009/2010 did not find an association with socio-economic status and SSB consumption (with the exception of Denmark for the survey year 2009/2010). However the study used the Family Affluence Scale (FAS) as a measure of socio-economic status which does not include educational or cultural dimensions of the socio-economic status construct. Robertson et al. (2007)[14] also highlighted the importance of low income *and* poor parental education as drivers for high SSB consumption.

3.1.1.2 How much of SSBs do people consume?

The review found several articles describing the amount of SSBs consumed. It is important to note that it is difficult to compare consumption patterns of SSBs across studies because consumption is presented in various ways such as by volume, frequency, percentage of total beverage intake, percentage of total caloric intake, and percentage of beverage calorie intake. However, the following patterns and trends were identified in the literature.

Adult SSB consumption

Adult Consumption of SSBs has been reported as grams consumed per day, servings per day, percent daily contribution of SSBs to total sugar intake or percentage of individuals consuming SSBs daily. The articles included in this review presented the following results:

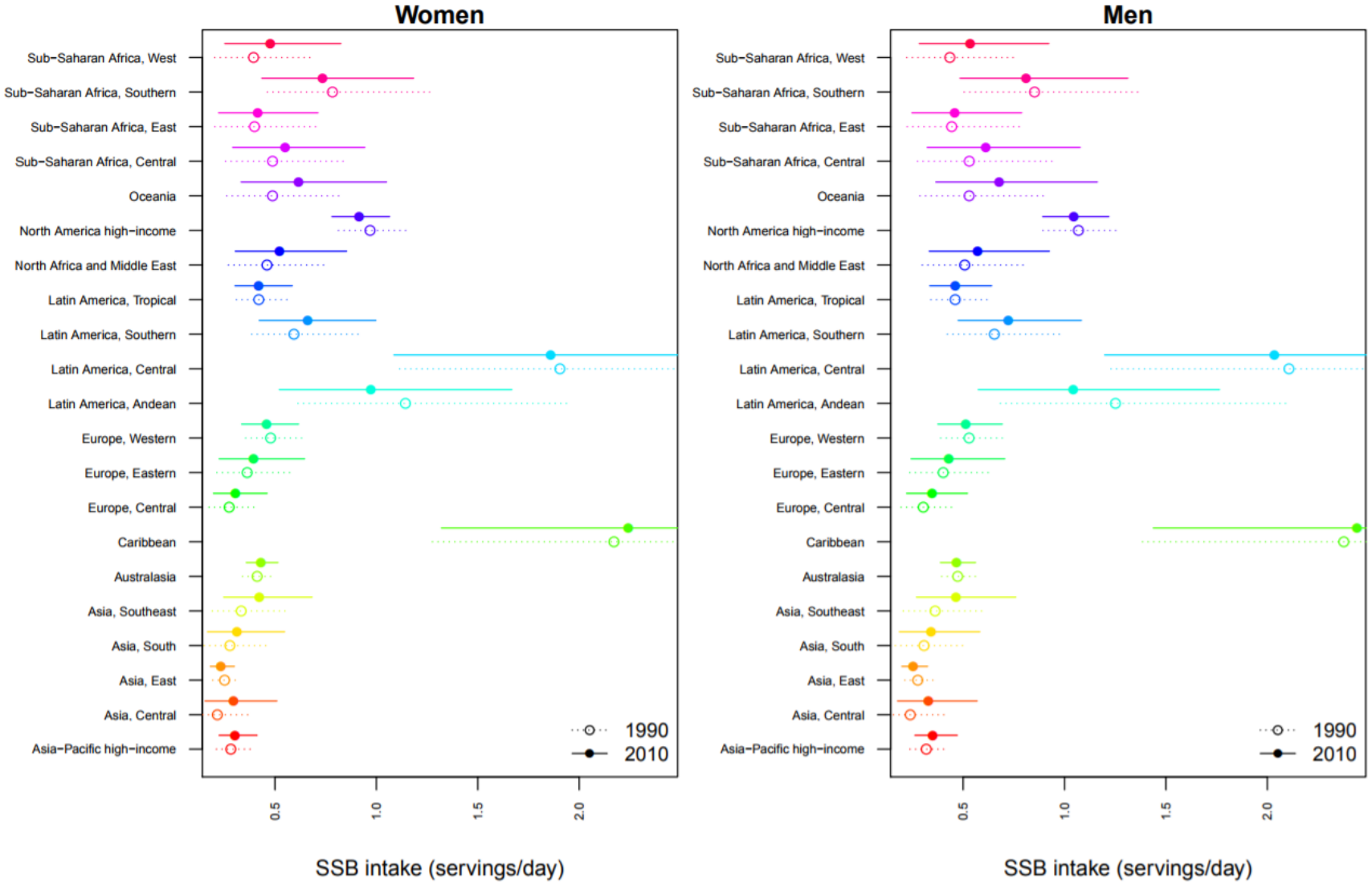
- **Global pattern.** Singh et al. (2015), using data from 193 nationally or sub-nationally-representative diet surveys worldwide, reported that in 2010, average global SSB consumption in adults over the age of 20 was 0.58 (95%UI: 0.37, 0.89) 8 oz servings per day. However there was **large variation in SSB consumption across regions** with almost a tenfold difference between highest and lowest regional intake levels (Figure 1). Out of 21 regions, SSB consumption was highest in the Caribbean (1.9 8 oz servings) and lowest in East Asia (0.20 8 oz servings). **European regions had relatively low levels of SSB consumption compared to other regions** (Singh et al. 2015).

[12] Authors collected data from 1st and 2nd grades at three time points

[13] Maternal education ≤12 years or >12 years was a proxy for SEP.

[14] The systematic literature review consisted of searching the Medline database for literature published between 1997-2007 using search terms 'obesity', 'prevention' or 'intervention' and 'inequality' or 'socio-economic', considering papers primarily of European origin.

Figure 1. Regional SSB consumption in 1990 and 2010



Source: Singh et al. (2015), Supporting information, Figure A.

- **European patterns.** Within Europe, **in 2010, Western Europe had the highest level of SSB consumption** while Central Europe had the lowest. However, between 1990 and 2010, Western Europe was the only European region to show a decrease in SSB consumption over time (see Figure 1 above).

  Breaking down data to MS level, the table below highlights findings from Azais-Braesco et al. (2017) which reviewed or re-analysed data from representative surveys in various European countries. The data represent the percent daily contribution of SSBs to total sugar intake, the age range, and gender of the surveyed countries.

Table 2. Percent daily contribution of SSBs to total sugar intake by gender

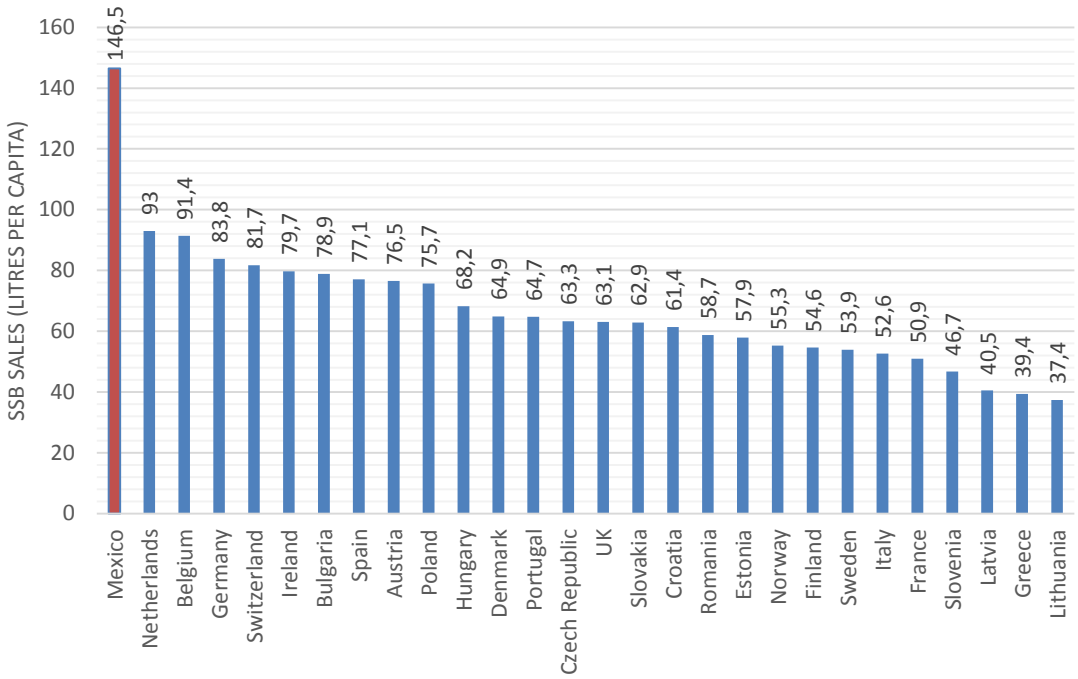
	Men	Women	Both Genders	Age Range
Belgium			19 (N=1316)	Over 15
France	7 (N=902)	5 (N=994)		18-74
Italy	4 (N=1068)	3 (N=1245)		18-65
Spain			11 (N=1655)	18-64
The Netherlands	16 (N=1054)	11 (N=1050)		19-69

Data for the UK included the percent contribution of SSBs (soft drinks, specifically) to the intake of non milk extrinsic sugars (NMES) in adults (age 19 to 64), but not the percent contribution of SSBs to total sugar intake. In the UK, SSBs make up 16% and 15% of consumed foods with added NMES among men and women, respectively (N=1126 for men and N=1571 for women). These data align with other findings in section 3.1.3.1 that suggest that men tend to consume slightly higher amounts of SSBs daily than women. Belgium, the Netherlands and Spain show the highest percent daily contribution of SSBs to total sugar intake.

From the grey literature, in 2016, the International Chair on Cardiometabolic Risk (ICCR) published their first ever SSB Sale Barometer, which lists the annual sales of soft drinks, juice drinks, energy drinks and sports drinks, using sales as a proxy for consumption (ICCR 2016). Results showed that Mexico, Chile and the US were the biggest consumers of SSBs, while in Europe, the Netherlands, Belgium and Germany are the biggest consumers of SSBs (Figure 2 below).

Increases in SSB sales between 2010 and 2015 were highest in Saudi Arabia, Vietnam and Georgia, while the biggest decreases were seen in Portugal, Greece and Croatia. **SSB sales decreased in almost all European countries except Denmark, Luxembourg and Belgium,** however reductions were partly offset by increases in energy drink sales. Energy drink sales are on the rise in almost all countries, except Ireland, Portugal and Finland.

Figure 2. SSB sales (litres per capita) in 2015



Source: ICCR 2016. Graph produced by ICF

Several studies were identified that looked at SSB consumption in individual MS. Due to the different units of measurement used, results are reported separately below:

- In **Spain**, a prospective cohort study of Spanish University graduates (N=3036) from (1993-2013) found that at baseline, the average consumption of SSB for all participants was 49.1 g/day but decreased to 20.3 g/day, or a 58.7% decrease in SSB consumption in ten years (de la Fuente et al., 2016. Grey literature results reported that in 2013, 42.7 litres of soft drinks (including cola, lemon- and orange-flavoured drinks, isotonic and tonic soft drinks, coffee/ tea flavoured soft drinks and soft drinks with juice and milk) were consumed on average per person (of which 22.1% was attributed to cola consumption) (Cerdeño 2014);
- In **Germany**, a representative sample (N=15,371) of the German population aged 14-80 who completed a diet history interview in 2005 or 2006 showed that on average, males consume 224 g/day and females consume 88 g/day of SSBs (Heuer et al. 2015);
- In a 2010-2012 sample (N=984) of the general population of Athens, **Greece**, the average energy intake from SSBs for men and women was 34 Kcal and 15 Kcal daily for summer and winter, respectively (Malisova et al. 2015); and
- In **Poland**, grey literature findings showed that, in 2000, 44% of interview respondents (N= 943 from a representative random sample of adult Polish citizens) reported that they avoid sweetened drinks (for example coca-cola, fanta and mirinda) completely, while 16% drink them several times a week, and 11% drink them every day. Only 17% of respondents considered that they drank too many sweetened drinks (Feliksiak 2014).

Youth SSB consumption

The data in the table below come from the same Azais-Braesco et al. (2017) article referenced above, but with a focus on youth rather than adults. Again, data is presented

as a percentage of SSB consumption as it relates to total daily sugar intake. Data for boys and girls was not included for Belgium in this study.

Table 3. Percent daily contribution of SSBs to total sugar intake by gender, children and adolescents

	Boys	Girls	Both Genders	Age Range
Belgium	NA	NA	NA	NA
France	11 (N=745)	9 (N=700)		3 -17
Italy	8 (N=108)	5 (N=139)		10-18
Spain			17 (N=211)	13-17
The Netherlands	25 (N=856)	21 (N=857)		7-18

Data for the UK included the percent contribution of SSBs (soft drinks, specifically) to the intake of NMES in children (age 4 to 18), but not the percent contribution of SSBs to total sugar intake. In the UK, SSBs make up 24% and 22% of consumed foods with added NMES among boys and girls, respectively (N=1409 for boys and N=1365 for girls). **Child and adolescent trends are roughly in line with the adult data reported above, with high SSB percent contribution to total sugar intake in the Netherlands.**

More broadly across all MS, grey literature data from the most recent 2014 Health Behaviour in School-aged Children study (HBSC, Inchley et al. 2016), highlighted **large variations in SSB consumption** (defined as sugar-sweetened soda). For example, 34% of 11 year old girls and 39% of 11 year old boys in Malta drink soft drinks every day, compared to 1% of 11 year old girls and 3% of 11 year old boys in Finland. At individual country level, the following consumption levels were identified. Studies have been ordered by the age of the study population, however comparison was not possible due to the different measurement styles used:

- In **Norway**, the Norwegian Mother and Child Study (N=9025) found that the median consumption of SSBs for Norwegian boys was 2 times/week at 18 months of age, 2.0 times/week at 36 months of age and 2.5 times/ week at 7 years of age. For girls, 1 time/week at 18 months, 2.0 times/week at 36 months and 2.5 times/week at 7 years (Bjelland et al., 2013).
- The Toybox Study, a cross sectional study of 4-6 year olds in **Belgium, Bulgaria, Germany, Greece, Poland, and Spain** (N=8,117 parents completing questionnaires) found that the mean intake of SSBs ranged from 13.2 ml/day in Greek pre-schoolers to 156 ml/day in Polish pre-schoolers (Craemer et al., 2015).
- A longitudinal survey of **Swedish** school children (7-9 year olds) in 2008 (n=833), 2010 (n=1085) and 2013 (n=1085) showed that 7.1% of students consumed SSBs 4-7 days/ week at baseline and 11.9% consumed SSBs 4-7 days/week at follow up (Moraeus et al., 2015).
- **Danish, Finnish, Norwegian, and Swedish** (N=6,000) cross sectional data from the International Health Behaviour in School Aged Children Study found that that the average proportion of students aged 11-15 years with daily consumption of SSBs was 15.3% (2001/2002), 11.7% (2005/2006), and 9.2% (2009/2010). Finnish students reported the lowest frequency of daily SSB

consumption (8.3, 6.2, 5.0) and Norwegian students reported the highest frequency (27.1, 17.4, 14.7) (Fismen et al., 2016).

- Fismen et al., (2016) observed decreased trends for SSB consumption among school-aged children in **Norway, Sweden, and Finland** (N=6,000). SSB consumption decreased between 2001 and 2006 and was stable thereafter using a repeated-measure cross-sectional design. In 2009/2010, the proportion of students with daily SSB consumption was 9.2%, a significant decrease from 2005/2006 (11.7%) and 2001/2002 (15.3%). Denmark displayed an increase in SSB consumption between 2001 and 2006, which was followed by a decrease between 2005 and 2010.

- In **Germany**, a representative sample (N=15,371) of people aged 14-80 who completed a diet history interview in 2005 or 2006 showed that on average,14-18 year old males consume 505 g/day of SSBs and 14-18 year old females consume 260 g/day of SSBs (Heuer et al. 2015).

Finally, grey literature research findings in **Poland, the Netherlands, the UK, Germany, France, Austria and Switzerland** reported by the Polish Expert group on intake of drinking water and other beverages by infants, children and youth, found that 27% of children aged 1-3 years, 21% of children aged 3-6 years and 22% of children aged 7-9 years drink SSBs on a daily basis (Woś et al. 2010). In **Italy**, Nardone et al. (2016) reported the results of an Italian Ministry of Health and Education survey (N=46,000 children aged 8-9 and 48,000 parents) which showed that in 2014, 41% of children had one or more sweetened beverages or fizzy beverages every day (no distinction was made between sugar-sweetened and artificially sweetened beverages), although consumption was heterogeneous across all Italian regions.

3.1.1.3 What are the drivers of SSB Consumption?

Drivers of SSB consumption can include personal characteristics and attitudes that make one more likely to consume SSBs, the overall food environment one is exposed to and social influence. **This review focusses on the wider social and environmental drivers of SSB consumption rather than individual drivers** (see exclusion criteria in Annex 1). However information on individual drivers has been included where available and illustrative. This section discusses drivers for childhood consumption of SSBs, followed by adult consumption.

Drivers of SSB consumption among children and adolescents

Paes et al.'s (2015) systematic review of 44 studies assessing the correlates of SSB consumption among children identified several individual, interpersonal, and environmental factors associated with SSB consumption. Their findings are supported by further individual studies identified in our review, as reported below. Factors associated with higher SSB consumption were:

- **child's preference for SSBs;**
- **TV viewing/screen time**. This finding was supported by Park et al.'s (2012) study in the US (N=11,209 adolescents aged 14-18) which found that eating fast food and watching television were associated with a higher likelihood of SSB consumption;
- **snack consumption**. Vargstrand et al., (2009) also found that among adolescents in Sweden (N=481) high SSB consumption was associated with infrequent breakfast consumption and high consumption of salty snacks;
- **parents' lower socioeconomic status;**
- **lower parental age**. This finding is supported by a longitudinal study by Pawellek et al. (2016) who, among a sample of children and their mother's from Germany,

Belgium, Italy, Poland and Spain (N=995) found that children's intake of SSBs is negatively correlated with mother's age;
- **parental SSB consumption;**
- **formula milk feeding;**
- **early introduction of solids;**
- **using food as rewards;**
- **parental-perceived barriers;**
- **attending out-of-home care;** and
- **living near a fast food/convenience store.**

Factors associated with lower SSB consumption were:

- parental positive modelling, also highlighted by Inchley et al. (2016);
- parents' married/co-habiting;
- school nutrition policy;
- staff skills; and
- supermarkets nearby.

The grey literature also found that children from **families where at least one parent is obese consume more sweetened beverages** compared to children who do not have an obese parent (Nardone et al. 2016)[15] and that **high availability of SSBs may explain the mixed relationship found between soft drink consumption and family affluence** highlighted in section 3.1.1.1 above (Inchley et al. 2016). In some countries and regions soft drinks are considered luxury items and are only affordable to those families with greater material wealth while in others they are cheap and highly affordable. The Paes et al. (2015) review discussed above also found indeterminate, but possible positive associations (3 of 7 intervention and cross-sectional studies) between the consumption of SSBs and their availability in the home.

Finally, there is some evidence that consumption of SSBs in early childhood may influence consumption behaviours later in life. Bjelland, et al.'s (2013) longitudinal study (N=9025 children with dietary behaviours assessed at 18 months, 36 months and 7 years) found that children classified as low, medium, and high frequency consumers of SSBs at 18 months of age consume SSBs and continue to be in the same group at age 36 months and 7 years. In line with this finding, grey literature findings suggest that **the consumption of SSBs from a young age may lead to the development of taste preferences for sweetened drinks and sugary foods.** It is well established in the scientific literature that early childhood is a critical period for the formation of eating habits (Woś et al. 2010). An evidence review by Lavin & Timpson (2013) reported that SSBs may alter long-term taste preferences toward increased sugary food and increase hunger and/or decrease feelings of satiety, with evidence that more infants and young children are developing taste preferences for sugary drinks from a young age (EU Framework for National Initiatives on Selected Nutrients, European Commission 2010).

Drivers of SSB consumption among adults

Among adults, the following main drivers for SSB consumption were identified in the literature:

- **Weight status and lack of concern about the healthfulness of foods was associated with SSB consumption among Australian adults.** According to a study by Pollard et al. (2016) (N= 2,832 Western Australians and N=10,764 Southern Australians aged 18-64), obese participants were more likely to drink SSB than healthy weight participants. Participants who paid less attention to the

[15] Data is from the 2014 results of the "Watch your health" surveillance system. Data has been collected every year since 2008 by the Italian Ministry of Health and Education. The survey was conducted in primary schools on around 46,000 children aged 8-9 years and on around 48,000 parents.

healthiness of their food were about five times more likely to be SSB consumers than those who reported paying a lot of attention to the healthiness of their food.

- **Stress may increase the consumption of SSBs.** A double-masked study of a diet intervention found that sugar, but not aspartame, inhibits the secretion of the stress hormone cortisol, leading to sugar overconsumption as a response to stress. In this study (Tryon et al. 2015) (N=19 women aged 18-40) participants consumed three beverages sweetened with aspartame or sucrose over a 12-day period and were assessed for stress using measurements of salivary cortisol and regional brain responses to the Montreal Imaging Stress Task.
- **Seasonality may influence SSB consumption.** In the study conducted by Malisova et al. (2015) the authors found that among a sample of 984 adults in Greece both men and women (aged 18-60) consumed more SSBs in winter compared to other seasons, and men consumed more than women.

The grey literature also identified price discounting in the UK (Tedstone et al. 2015) and marketing and advertising (Sjolin 2006) as key drivers of SSB consumption. Tedstone et al. reported that price discounting on high sugar products in stores increases the purchasing of food and drinks brought into the home by 22%. Because promotions are continually refreshed they appear to have a sustained effect in the UK market, and are likely to have a greater effect than even the largest tax introduced internationally. The low cost of sugary drinks may also encourage individuals to drink larger servings (Jacobson 2005).

3.1.2 Research question 2: Who consumes fruit juices, how much do they consume and what are the drivers behind such choices?

As mentioned above, unless specified, references to fruit juice in this section refer only to drinks that contain 100% fruit juice. This section refers mainly to peer reviewed references as limited grey literature was identified.

Summary

- At European level, average daily fruit juice consumption varies by MS. Limited evidence identified Germany, Finland, Austria, the Netherlands and Slovenia as the biggest consumers of fruit juice.
- More generally, fruit juice consumption was found to be higher in higher income countries, and among males (compared to females). While globally no correlation between fruit juice consumption and age was identified, in some developed nations there is some evidence that younger age groups consume more fruit juice than older age groups. In a number of European countries, babies and very young children are regularly consuming fruit juice.
- Limited evidence suggests that seasonality, mothers' fruit juice consumption and mothers' SES may act as drivers for fruit juice consumption.

3.1.2.1 Who consumes fruit juice and how much do they consume?

The following trends in fruit juice consumption were identified:

- **Average daily intake of fruit juice varies by country.** By assessing data from 193 national and subnational diet surveys and food balance information from the UN Food and Agriculture Organization, Singh et al. (2015) report that in 2010, global average adult consumption was 0.16 8 oz servings per day of fruit juice per

person. Fruit juice consumption was highest in Australia and New Zealand and lowest in East Asia and Oceania.

- At European level, Elmadfa and Meyer (2015) conducted a secondary analysis of data from the European Food Safety Authority's Concise Food Consumption Database to examine drinking and eating patterns across the European Union. Analyses on beverage consumption patterns focused on 19 countries[16]. Adults in Italy, Slovakia, Poland and Ireland had the lowest average daily consumption of fruit and vegetable juices (30 ml/day, 31 ml/d, 32 ml/d and 33 ml/d, respectively); adults in Germany, Finland, Austria, Netherlands and Slovenia had the highest average daily consumption (226 ml/d, 165 ml/d, 147 ml/d, 130 ml/d and 128 ml/d respectively)[17].
- **Fruit juice consumption is higher in higher income countries.** Fruit juice consumption increased in higher income countries (0.25 servings/day, 95%UI: 0.18, 0.36) and was lowest in low income countries (0.03 servings/day, 95%UI: 0.02, 0.06) (Singh et al. 2015).
- **Average daily intake of fruit juice varies by gender: males consume more fruit juice than females.** Four of the five studies identified in this review found that males consume more fruit juice than females.

  Looking at global patterns, Singh et al. (2015) found that in 2010, regional consumption of fruit juice was highest in men aged 20–39 in the Caribbean at 3.4 (95%UI: 2.0, 5.6) servings/day and lowest in women over age 60 in East Asia (0.12, 95%UI: 0.09, 0.15 servings/day). In the cross-sectional studies by Heuer et al. in Germany (N=15,371 adolescents and adults aged 14-80) and Vagstrand et al. in Sweden (N=481 adolescents age 16), **among adolescents**, boys consumed nearly 90 ml more fruit juice per day on average when compared with adolescent girls[18]. A significant but smaller difference was observed by Duffey et al.'s (2012) multi-country study of adolescents (N=2,471 aged 12.5-17.5) from Belgium, Bulgaria, France, Greece, the Netherlands, Portugal and Romania, with adolescent boys consuming 143 ml/d and girls 123 ml/d. It is important to note that the smaller difference in the latter study may be due to the fact that the study analysed data on consumption from seven countries and could therefore reflect both gender and country variation in fruit juice consumption.

  Among adults aged 14-80 in Germany, Heuer et al. (2015) noted that on average, adult males consumed 285 ml of fruit juice per day and adult females 245 ml/d. When stratifying by age group (see Table 4) these gender differences remained with the exception of the oldest age group, where, among adults aged 65-80 years, females consumed more fruit juice per day than males (179 ml/d versus 145 ml/d).The one study that did not find a significant difference in adult (aged 18-60) consumption was based in Greece and the primary objective of the study was to assess possible differences in beverage consumption by season (Malisova, 2015). It should also be noted that in this sample the variation of fruit juice consumption reported by females was much greater than of males (44-134 kcal/day versus 14-44 kcal/day).
- **There is some evidence that younger age groups consume more fruit juice than older age groups.** While globally there is little connection between age and

[16] Denmark, Finland, Sweden, Latvia, Estonia, Austria, Czech Republic, Germany, Poland, Slovakia, Slovenia, Belgium, France, Ireland, the Netherlands, United Kingdom, Italy and Spain.

[17] This article did not make clear whether fruit juice referred to only 100% fruit juice.

[18] It should be noted that the Vagstrand and Heuer articles do not clearly define "fruit juice" though norms in this research suggest that their study refers to 100% fruit juice beverages.

fruit juice consumption (Singh et al. 2015), within some developed nations there may be a correlation at least in part due to the widespread availability of fruit juice. For example, considering a serving of fruit juice to be 150ml, in Germany, Heuer et al. (2015) found that males aged 14-18 consumed nearly 3.25 servings and males aged 35-50 consumed 1.85 servings. Similar trends were found among females with 14-18 year olds consuming 2.68 servings on average and females aged 35-50 consuming 1.56 servings on average. A full summary of the study's findings is presented in Table 4.

Table 4. Summary of Average Fruit Juice Consumption Per Day Among German Adults Stratified by Age and Gender

	Aged 14-18	Aged 19-24	Aged 25-34	Aged 35-50	Aged 51-64	Aged 65-80
Males	488g/d	382g/d	379g/d	288g/d	202g/d	145g/d
Females	403g/d	357g/d	321g/d	234g/d	181g/d	179g/d

Source: data taken from Heuer et al. 2015; table by ICF

Francou et al. (2015) quantified 100% fruit juice consumption among children and adults in France but found smaller differences than those observed by Heuer et al. (2015) in Germany. In their study of 809 children (aged 3-14) and 1,121 adults (aged ≥21), children (aged 3-14) consumed 30ml more fruit juice per day than adults (83ml/d versus 55ml/d, respectively). In addition, the authors found a smaller percentage of children (aged 3-14) reporting that they did not consume fruit juice when compared with adults (30% of children and 50% of adults) (Francou et al. 2015). Both studies relied on self-reports of dietary behaviour.

- **Babies and very young children are consuming fruit juice.** A grey literature study (Woś et al. 2010) using research findings from Poland, the Netherlands, the UK, Germany, France, Austria and Switzerland, reported that 8% of children aged 1-3 years, 10% of children aged 3-6 years and 10% of children aged 7-9 years drink juice on a daily basis, higher than the recommended volume. Furthermore, a literature review conducted by the Spanish Association of Dieticians and Nutritionists (2006) reported that the consumption of fruit juices by children and adolescents has seen a significant increase over the last few decades.

3.1.2.2 What are the drivers behind fruit juice consumption?

Key findings include:

- **Seasonality may play a role in fruit juice consumption.** Malisova et al.'s (2015) assessment of the impact of seasonality on beverage consumption[19] found that among adults (18-60) in Greece, fruit juice consumption accounted for 3.3% of total energy intake in winter and 2.1% in summer. However, no significant difference was found in the number of calories consumed from fruit juice in winter versus summer;
- **Mothers' fruit juice consumption may influence child consumption.** Vagstrand et al. (2009), assessing dietary behaviours of mothers and their children in Sweden found that mothers' consumption of fruit juice is positively associated with child fruit juice consumption (Vagstrand et al., 2009);
- **In some European countries the low socio-economic status of mothers was associated with higher fruit juice consumption among their children.** In their multi-country study of child (aged 6-8) health behaviours, Mantziki et al. (2015), collected data from 1,266 families from six European countries (Belgium, Bulgaria, France, Greece, Portugal and Romania). The authors noted that in analysing data for the whole sample, mothers of low educational attainment had children who consumed more fruit juice. However, running analyses for each country separately, a significant relationship was only found in Belgium, Bulgaria and Romania. Mothers with low educational attainment also reported rewarding/comforting their children with fruit juice more frequently than mothers of high educational attainment; and
- **Associations between fruit juice consumption and other dietary characteristics are not clear.** In their study of children and their parents in France, Francou et al., (2015) found that those who consume more fruit juice tend to have healthier diets overall. In contrast, Vagstrand et al. (2009) found that among Swedish adolescents, a higher intake of fruit juice was associated with a higher intake of sugary foods, higher intake of fruits and a lower intake of milk.

[19] This study also examined consumption of other beverages including sugar sweetened and artificially sweetened beverages.

3.1.3 Research question 3: Who consumes LCS beverages, how much do they consume and what are the drivers behind such choices?

Summary

- There is limited European-level data on LCS consumption patterns and levels: most available data is from the US.
- LCS consumption in the US has increased over the last 20 years and this trend is expected to continue worldwide.
- Findings suggest that females are more likely to consume LCS beverages than males and there is limited evidence to suggest a positive association between LCS consumption and SES. Links between age and LCS consumption were also identified but varying patterns were reported.
- Limited information from individual MS on drivers of LCS consumption suggest that obese individuals may be more likely to consume LCS beverages compared to those with a healthy weight and that more LCS beverages may be consumed in winter compared to summer.

3.1.3.1 Who consumes LCS beverages and how much do they consume?

As mentioned above in section 1.1, for the purpose of this review, non-nutritive, low-calorie, and zero-calorie sweeteners are all treated as one category and abbreviated as "LCS" and exclude (apart from sucrose and HFCS) other sweeteners containing sucrose or fructose such as honey or agave. The review found very few references focussing on European LCS consumption patterns, with most reliable national level estimates limited to data from the US. According to Sylvetsky & Rother (2016) studies have been conducted in Canada, Brazil, Denmark and South Korea, however only the average volume of LCS beverages consumed is reported, not the percentage of the population consuming LCS beverages. Despite these limitations, the following patterns and trends were identified:

- **Approximately a quarter of adults and a fifth of youth in the US consume beverages with LCS.** Using data from the National Health and Nutrition Examination Survey (NHANES), Sylvetsky & Rother (2016) reported most recent estimates (2009-2010) of LCS consumption to be approximately 24.9% of the adult population and 18.9% of the youth population.
- **The US has seen an increase in the consumption of LCS beverages; this trend is expected to continue worldwide.** Sylvetsky and Rother used data from the Nielsen Homescan, which uses household purchases of beverage products as a proxy for estimating consumption patterns. Increases in the percentage of households purchasing LCS containing beverages were reported from 1999 to 2010. Homescan and NHANES data both showed that in youth and adult populations, the consumption of LCS beverages increased primarily due to increased consumption of reduced-calorie beverages (e.g. light fruit drinks), while consumption of no-calorie beverages like diet soda remained relatively stable. The authors concluded that consumption of LCS has increased in the US, and will continue to increase worldwide.
- **Two studies were found that quantified LCS consumption in Norway and the UK.** Among adults aged 18-70 in Norway (N=1787), Paulsen et al. (2016) found average consumption of LCSs to be 400 ml/d. Data were collected via a cross-sectional dietary survey administered at two time points (one weekday and one weekend day) in 2010-2011 which included a 24-hour dietary recall. In the UK, LCS beverages make up 44% by weight of all soft drinks

consumed by adults 19-64 (Gibson, 2016), a higher proportion than in other European countries. This study examined beverage consumption from the UK National Diet and Nutrition Survey from 2008 to 2011 (N=1590).

- **Females are more likely to consume LCS beverages than males.** Sylvetsky & Rother (2016) found that increases in LCS beverage consumption in the US between 1999 and 2008 (NHANES data) were higher among females than males and in 2009-2010 (NHANES data), LCS beverage consumption among girls ages 12-19 was higher than male peers. In Norway (Paulsen et al. 2016) women had 38% higher odds of consuming artificially sweetened beverages compared to men and in an Australian study of 2,832 adults from Western Australia and 10,764 adults from Southern Australia aged 18 to 64 (Pollard et al., 2016), LCS consumption was also found to be higher among females. In contrast, a study in Greece focussing on seasonality of beverage consumption found that consumers of LCS beverages tended to be male (Malisova et al., 2015). However this may be a function of the fact that the authors main objective was to assess differences in beverage intake across seasons.
- **There is some evidence suggesting a positive association between LCS consumption and SES.** While NHANES trend data between 1999-2008 found no link between SES and LCS consumption in the US, more recent (2009-2010) NHANES data found that LCS beverage consumption is positively associated with SES, with families with the highest SES reporting the greatest prevalence of LCS use (Sylvetsky & Rother 2016) .
- **There is some evidence linking LCS consumption and age.** In the US, Sylvetsky & Rother (2016) found that increases in LCS beverage consumption were highest among children 6-11 years old and adults aged 55 or older, while in Norway, Paulsen et al. (2016) reported that older age was negatively associated with ASB consumption.

3.1.3.2 What are the drivers associated with LCS beverage consumption?

Limited information was found on drivers of LCS beverage consumption. Among Norwegian adults (Paulsen et al. 2016) LCSs were consumed more often during snack times; overweight individuals had higher odds of consuming LCS beverages compared to those with a healthy or low weight[20] while people interested in a nutritionally balanced diet had 21% lower odds of consuming LCS beverages compared to individuals with no, low or moderate interest. There was no evidence that LCS consumption patterns differed between weekdays and weekend, however in Greece, Malisova et al. (2015) found that respondents (N = 984; 473 individuals in summer and 511 individuals in winter) consumed significantly more LCS beverages in winter compared to summer.

[20] Paulsen et al., used self-reported height and weight to calculate BMI. BMI was recoded into a dichotomous variable for analysis (<25 kg/m^2 and ≥25kg/ m^2)

3.1.4 Research question 4: What are the consequences of such consumption on overweight and obesity?

Summary

- **SSBs.** There is strong evidence showing that SSB consumption leads to increased weight status, BMI and/or body fat in both children and adults. SSB consumption has also been linked to tooth decay, obesity-related health problems and nutrient deficiencies.
- **Fruit juice.** No evidence was found to support a positive association between fruit juice consumption and weight/BMI. There is currently a lack of randomised controlled clinical trials on this topic to support a causal relationship.
- **LCS beverages.** There is no conclusive evidence that consumption of LCS beverages is associated with changes in body weight or body fat. However evidence from peer reviewed systematic review supports an association between consumption of artificially-sweetened beverage consumption and weight gain in children. There is also some evidence that *replacing* SSBs with LCS beverages can reduce existing body fat.

3.1.4.1 SSB Consumption and Overweight/Obesity

Increases in overweight and obesity over the last 30 years has been charted against the increase in SSB consumption over a similar time period, leading many to argue that SSBs are a major contributor to the obesity epidemic.

Ample research demonstrates a positive relationship between SSB consumption and weight status, BMI and/or body fat in both children and adults. Multiple reviews support this finding including a seminal, systematic review conducted by Malik, Schulze, and Hu (2006) of research studies published from 1966 to 2005. The authors concluded that greater consumption of SSBs is associated with weight gain and obesity in children and adults based on thirty English-language studies (15 cross-sectional, 10 prospective, and 5 experimental). A more recent review conducted by Malik, Pan, Willett, and Hu (2013) looked across 32 prospective cohort studies and randomized control trials (20 pertaining to children and 12 pertaining to adults) and concluded that SSB consumption promotes weight gain in children and adults.

Further, in a meta-analysis of 88 studies focused specifically on sugar-sweetened soft drink consumption, Vartanian and colleagues (2007) found a clear association between soft drink intake and both total energy intake and body weight. The authors noted larger effect sizes in body weight were found in experimental studies (compared to less rigorous designs) and in studies that were not funded by the food industry, as well as larger effect sizes in body weight among women and adults.

Multiple recent studies further support the link between SSB consumption to overweight and obesity. For example, in a prospective, longitudinal study using a randomly generated, population-based sample (N=2,181) of Spanish men and women aged 25 to 74, Funtikova et al. (2015) found positive associations between SSB consumption and body weight. The authors found that each 100 kcal of SSB consumption was associated with a 1.1 cm increase in waist circumference. Furthermore, substitution of 100 kcals of SSBs with 100 kcal of milk was associated with a 1.3cm decrease in waist circumference and substitution with 100kcal of juice was associated with a 1.1 cm decrease in waist circumference. Assessments of the sample were conducted in 2000 and 2009 and included waist circumference measurements and self-reported diet via a food frequency questionnaire including 166 food items.

Papandreou and colleagues (2013) found that children and adolescents aged 7 to 15 (N=607) attending schools in Thessaloniki, Greece who consumed SSBs were 2.57 times more likely to become obese than their peers who did not consume SSBs. SSB consumption was measured using a 24-hour recall technique over three days; body weight was measured by a digital scale. In contrast to SSBs, the authors found no association between body weight and 100% fruit juices or milk.

Similarly, a cross-sectional study using a small sample of 74 overweight adolescents in Canada (Mollard et al. 2014) found that frequent consumption of soda, along with available carbohydrate, were positively associated with visceral obesity, though not with hepatic steatosis (the authors examined soda consumption in isolation, along with the broader category of SSBs including sweetened ice tea and fruit drinks, for which they found no association)[21].

Finally, the link between the consumption of SSBs and weight gain and/or obesity has been noted by multiple grey literature sources (Sjolin 2006; European Commission 2007; European Commission 2010; European Food Safety Authority 2010; Bury 2012; Tedstone et al. 2015; and Walsh 2015), particularly among children (European Observatory 2005; Woś et al. 2010; Inchley et al. 2014; Walsh 2015; Nardone et al. 2016; Pinkas 2016). One grey literature study, The DONALD[22] study (Buyken et al. 2012) conducted in Dortmund, Germany since 1985 to examine complex relationships between nutritional intake, metabolism and growth from infancy to adulthood, also suggests a **potential relationship between gender and increased BMI as a result of SSB consumption**: the study only found a correlation between the consumption of sugar-sweetened drinks and a higher BMI in girls (no explanation was provided for why the relationship was not also observed in boys). However, such evidence is by no means sufficient to suggest that this gender difference occurs in other Member States or even in populations other than the study population. Sjolin's (2006) literature review also highlighted several studies that found that liquid calories may be *more likely* to promote obesity than solids, however further evidence is required to substantiate this claim.

Other potential side effects of consuming SSBs

Grey literature reviewed shows that sweetened beverages have also been linked to the tooth decay (Tedstone et al. 2015; EFSA 2010; Inchley et al. 2016); obesity-related health problems (Tedstone et al. 2015) including increased risk of type 2 diabetes (Walsh 2015; EFSA 2010; Olimpi 2012), cardiovascular disease (Olimpi 2012), and chronic diseases in general (Inchley et al. 2016). Decreased nutrient density and nutrient deficiencies were also identified as a potential side effect of SSB consumption (Inchley et al. 2016; EFSA 2010), including calcium deficiencies (Jacobsen 2005) which can lead to increased risk of osteoporosis, and malnutrition in children and adolescents (Woś et al. 2010) due to increasing the simple carbohydrate content of the diet and limiting the intake of other nutritional products.

3.1.4.2 Fruit Juice Consumption and Overweight/Obesity

Despite the potential nutritional benefits of fruit juices, they are high in natural sugar and calories; therefore, the potential impact of fruit juice consumption on weight is deserving of consideration.

[21] The study measured visceral obesity by magnetic resonance imaging (along with hepatic steatosis by magnetic resonance spectroscopy) and dietary intake with the Harvard Youth Adolescent Food Frequency Questionnaire.

[22] Approximately 40 infants are newly recruited into the DONALD study every year. Examinations are conducted at ages 3, 6, 9, 12, 18, 24 months and then annually until young adulthood and comprise anthropometry, a 3 day weighed dietary record, a 24 h urine sample (from age 3-4 years onwards), medical examinations and parental interviews. Since 2005 participants are invited for follow-up visits during adulthood (including fasting blood samples). Approx. 14,000 children have been recruited into the study up to 2010. (Buyken et al. 2012).

However, no evidence was found in the peer reviewed literature to support a positive association between fruit juice consumption and weight/BMI. In the research study by Vagstrand et al. (2009), the authors examined the relationship between BMI and fruit juice consumption among Swedish adolescents (N=481). The authors did not find an association between fruit juice consumption and BMI and hypothesized this could be because adolescents replace beverage consumption, particularly fruit juice, with meals/food. Furthermore, in a study by Shefferly, Scharf and DeBoer (2016), longitudinal analysis of 8,950 children aged 2, 4 and 5 years in the US found that although children who consistently drank fruit juice at age 2 had higher odds of becoming overweight by age 4, between ages 4 and 5 no difference in the prevalence of overweight and obesity was observed between consistent juice drinkers and inconsistent/non-drinkers.

In a separate systematic review by Crowne-White et al. (2016), similar findings were identified from the review of 22 studies. The studies included were published between 1995 and 2013 and focused on dietary intake and weight status of children between the ages of 1 and 18. After controlling for energy intake, the authors did not find any evidence of an association between weight status and fruit juice consumption. There is currently a lack of randomised controlled clinical trials on this topic to support a cause-and-effect relationship between 100% fruit juice intake and overweight or obesity.

3.1.4.3 LCS Beverage Consumption and Overweight/Obesity

As noted earlier, LCS beverage consumption has increased in recent decades. Although LCS beverages are often viewed as an alternative to SSBs for maintaining energy balance and weight (without increasing the total number of calories consumed), the effects of artificial sweeteners remains in question as well as whether LCS beverages produce a metabolic effect that results in weight gain.

Systematic reviews of research reveal little evidence that consumption of LCS beverages is associated with higher body weight. Miller and Perez (2014) examined studies of LCSs consumed from foods, beverages, and table sweeteners; nine prospective cohort studies showed that LCS intake was not associated with body weight or fat mass, but was significantly associated with slightly higher BMI. In a separate review, Rogers (2016) examined consumption of low-energy sweeteners (LES) in animal and human studies and found that twelve prospective cohort studies in humans reported inconsistent associations between LES use and body mass index. Anderson et al. (2012) also summarized observational studies examining the role of LCS in weight management and their impact on diet quality; the authors concluded that existing literature provides no evidence that LCS beverage consumption *causes* higher body weight in adults.

However, with regard to **children**, Brown, de Banate, and Rother (2010) systematically reviewed studies of artificial sweetener consumption in children and found that large, epidemiologic studies support an association between consumption of artificially-sweetened beverage consumption and weight gain in children.

Longitudinal studies demonstrate mixed results regarding the association between LCS beverage consumption and body fat. In one study, Fowler et al. (2015) reported a "positive dose-response relationship between initial diet soda intake and subsequent long-term increases in waist circumference, over a mean total follow-up of almost a decade" (Fowler et al. 2015, p.7). Notably, mean change in waist circumference over the study period was almost three times as great among LCS consumers as it was among non-consumers; among daily consumers, this increase was four times as great. Study participants (N=749) formed a bi-ethnic cohort of older adults (European- and Mexican-American at least 65 years of age at baseline

measurement) who were part of the San Antonio Longitudinal Study of Aging (SALSA)[23].

However, in a different longitudinal study, Ma et al. (2016) found no relationship between self-reported LCS consumption and body fat, but did observe greater increases in body fat associated with higher SSB consumption[24]. The study sample (N=1,003) included predominantly white adults (≈ aged 35-54) drawn from the Third Generation cohort of the Framingham Heart Study, a multi-generational longitudinal study of factors that contribute to cardiovascular disease.

Experimental studies also show mixed results regarding LCS beverage consumption and *weight loss*. Miller and Perez (2014) found that LCS beverage consumption modestly but significantly reduced body weight, BMI, and weight circumference based on a meta-analysis of 15 randomized controlled trials. However, Reid and colleagues (2016) found that evidence of longer-term metabolic effects of non-nutrient sweeteners (NNS) in youth are limited and inconsistent; they reported contradictory effects on weight change in children exposed to NNSs based on two RCTs. Similarly, Brown et al. (2010) found that the few controlled research studies conducted on children fail to demonstrate either positive or adverse metabolic effects of artificial sweeteners.

However, there is some evidence that replacing SSBs with LCS beverages can reduce existing body fat. Campos et al. (2015) examined the effects of LCS versus SSB consumption by randomly assigning a sample of 31 overweight high consumers of SSBs (stratified by gender) to either a control condition that continued to consume SSBs or to an experimental condition that replaced SSBs with LCSs. After 12 weeks, the group that received LCSs decreased body fat (as measured by intrahepatocellular lipid concentrations (IHCL)[25]) to 74% of baseline whereas no changes were observed in the control group.

De Ruyter et al. (2012) also found that masked replacement of an SSB (specifically a sugar-containing, noncarbonated beverage) with a noncarbonated LCS led to statistically significant reductions in weight gain and body fat gain, as measured by skinfold-thickness, waist-to-height ratio, and fat mass. The beverages were made to look identical and were distributed to 641 children between 4 years and 10 months and 11 years and 11 months in age over 18 months, with 477 completing the study.

3.1.5 Research question 5: Who consumes sweetened alcoholic beverages (artificially or sugar-sweetened), namely alcopops and sweetened spirit drinks that are pre-mixed, how much do they consume and what are the drivers behind such choices?

This section specifically focusses on consumption of alcopops and pre-mixed alcoholic beverages as defined in the introduction of this review (section 1). Discussion of alcoholic beverages more generally (for example beer, wine and spirits) is out of scope, although we acknowledge that the sugar content of such alcoholic beverages can be very high.

[23] Participants were assessed four times over a period that was 9.41 years long on average (ranging from 7.4 to 12.5 years long). Assessments consisted of measurement of waist circumference at the umbilicus, as well as fasting plasma glucose values, height, weight, and diabetic status, as well as physical activity and ASB soda consumption estimated from self-report.

[24] Participants' abdominal fat tissue (both visceral adipose tissue (VAT) and subcutaneous adipose tissues (SAT)) was measured via CT scan before and after a single interval of approximately six years.

[25] Intraheptocellular lipid (IHCL) concentration refers to the concentration of fat cells in the liver. High concentrations of IHCL have been associated with insulin resistance and high amounts of abdominal fat (Marchesini et al., 2001; Thamer et al., 2004).

Summary

- Alcopop consumption is highest among adolescents and young adults. However, in European MS, with the exception of Lichtenstein, alcopops were not found to be the most popular alcoholic drink among adolescents.
- Adolescent girls are more likely to consume alcopops than boys. There is limited evidence that alcopop consumption may be positively associated with SES and parental education.
- Targeted marketing and the sweet taste of alcopops were identified as drivers for consumption among adolescents. However evidence was limited to grey literature.

The literature identified the following main patterns of alcopop consumption:

- **Alcopop consumption is higher among adolescents and young adults than older adults.** Heuer et al. (2015) (N=15,371 adults aged 14-80 from the second German National Nutrition Survey) found that adolescents and young adults aged 14-24 had the highest consumption of alcopops and other spirit drinks (no distinction was made with regard to the type of spirit) compared to other age groups. Similarly, in an Australian experimental design study (Copeland et al. 2007) using a convenience sample of 350 participants aged 12-30 years old, alcopops (referred to as Ready-to-Drinks (RTDs)) were found to be most commonly the first used and most preferred alcoholic beverage among the youngest age groups. The mean age of initiation to alcohol use for the total sample was 13.6 years (when a parent introduced the youth to alcohol, initiation decreased to 12.8 years); and RTD products were more likeable than other types of alcohol among those aged 18 or under. The authors concluded that RTD products have the potential to increase the likelihood of adoption of alcoholic beverages among young adolescents, as it reduces the otherwise powerful and unpleasant flavor and taste of alcohol (Copeland et al. 2007).

Furthermore, Metzner and Kraus' literature review (2008) found that younger girls more regularly drink alcopops than conventional alcoholic beverages like beer. However, the study found no sufficient evidence to support the claim that alcopop consumers begin consuming alcohol at an earlier age, nor do they have earlier experiences of intoxication.

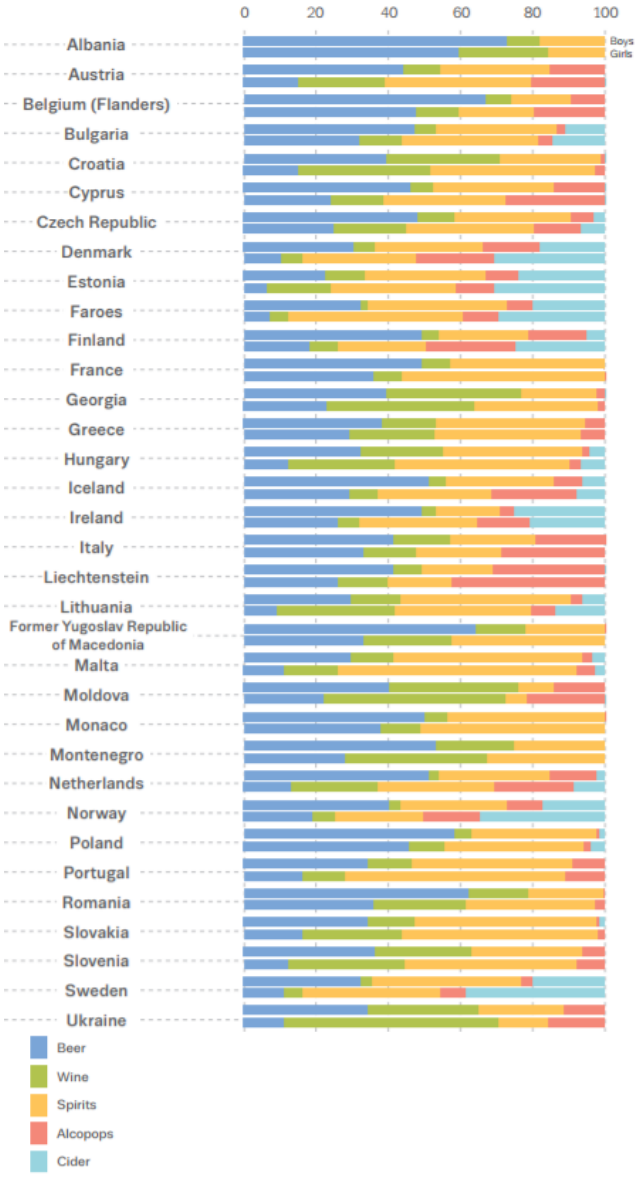
Grey literature findings also concluded that alcopops are particularly popular among teens and adolescents (Rabinovich et al. 2009; Alcohol Justice and the San Rafael Alcohol & Drug Coalition 2015). However, in contrast to the findings of Copeland et al. and Metzner and Kraus above, several sources of grey literature reported that **alcopops are not the most popular alcoholic drink among adolescents in most EU countries** (ESPAD 2015; Sierosławski 2015; Anderson, Suhrcke and Brookes 2012; PBS DGA 2007; Hemström, Leifman, and Ramstedt 2001, referenced in Anderson & Baumberg 2006), compared to wine, beers and spirits.

2015 ESPAD data[26] found that, on average, beer (35 %) and spirits (34 %) were the preferred alcoholic beverages and alcopops were the alcoholic drink of preference only

[26] The ESPAD data set (the European School Survey Project on Alcohol and Other Drugs) is conducted every four years with over 100,000 students across a large number of European countries (Armenia, Austria, Belgium (Flanders), Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, the Faroe Islands, Finland, France, Germany (7 Bundesländer), Greece, Hungary, Iceland, Ireland, the Isle of Man, Italy, Latvia, Lithuania, Malta, Monaco, the Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, the Slovak Republic, Slovenia, Sweden, Switzerland, Ukraine and the United Kingdom). The main purpose of the

in Liechtenstein (36%). However, in Cyprus, Finland, Italy and Liechtenstein, alcopops account for one fifth or more.

Figure 3. Beverage preferences (ESPAD 2015) (boys presented in top bars, girls in bottom bar)



At MS level, a study in Poland by the market research company PBS DGA (2007) used the same set of questions as ESPAD to look at alcohol and drug use in Krakow in 2007 among 2,038 high school and secondary school students. They found that 20% of boys, and 7% of girls tried alcopops when aged 13 or younger, and 14% of boys and 75% of girls had tried alcopops between the ages of 14 and 15. Similarly, Dzielska et al. (2015) using 2014 HBSC data found that 1.7% and 2.3% of boys, and 0.7% and 0.9% of girls, with an average age of 13 and 15 respectively, drink alcopops every day in Poland.

- **Adolescent girls are more likely to consume alcopops than boys.** Metzner and Kraus' (2008) review of the literature reported that girls tended to prefer alcopops whereas boys showed a preference for consuming beer. Similarly, girls

ESPAD project is to collect comparable data on substance use among 15-16 year old students. Data collection consists of school surveys, using a common methodology and questionnaire.

reported higher frequency of alcopop consumption compared to boys. ESPAD (2015) results further highlights this pattern across Europe: 11% of girls and 7% of boys (aged 15-16) preferred alcopops. In the Netherlands, a grey literature report by Muller and de Greeff from the Dutch Institute for Alcohol Policy (2013), using secondary data sources, also reported that female students in the Netherlands report drinking alcopops more than male students.

- **There is limited evidence that alcopop consumption may be positively associated with SES and parental education.** One grey literature review (Anderson, Suhrcke and Brookes 2012) reported evidence that adolescents (15-16 year olds) living in richer households tend to drink more overall than those living in poorer households, including more alcopops and spirits. The review also reported a potential link between a higher level of parental education and younger males having a lower likelihood of drinking alcopops.

What are the drivers of sweetened alcoholic beverage consumption?

No peer reviewed evidence was found to answer this question. However, the grey literature highlights a number of factors that influence the consumption of alcopops, particularly among adolescents, namely:

- **Advertising.** Winpenny et al. (2012), using secondary commercially available data on TV audiences and alcohol advertising[27] found that in the UK, young people aged 10-15 years are exposed to 51% more advertising than those aged 25, particularly for pre-mixed drinks, such as alcopops. The report concluded that exposure to alcohol adverts increases the likelihood that young people will start to drink alcohol from an early age. Furthermore, Alcohol Justice, and the San Rafael Alcohol and Drug Coalition (2015) argue that alcohol producers promote alcopops as a transition beverage that bridges the gap between soft drinks and alcohol for new drinkers;
- **Taste.** Alcopops are appealing to adolescents because of their sweet taste, extensive variety of flavours and high alcohol content (Alcohol Justice and the San Rafael Alcohol & Drug Coalition 2015); and
- **Low price and widespread availability** (Alcohol Justice and the San Rafael Alcohol & Drug Coalition 2015). However this finding was for the US and may not be applicable to European markets.

3.1.6 Research question 6: What are the consequences of such consumption on alcohol-related harm?

> ***Summary***
>
> - At present, there is not enough evidence to support a relationship between alcopop consumption and increased alcohol use, heavy episodic drinking and negative alcohol-related consequences. More studies are required that control for other forms of alcohol consumption.

As illustrated in earlier sections of this report, alcopops and other ready-made, sugar sweetened alcoholic beverages increased in popularity across Europe over the latter half of the 1990s (Metzner & Kraus, 2008). Their rising popularity resulted in concern that alcopops could be a major contributor to alcohol-related harm and negative health consequences. Metzner and Kraus' review of the literature investigated the

[27] The report used descriptive statistics and regression analysis to estimate exposure of young people to alcohol compared to adults and analysed a sample of alcohol adverts broadcast in those countries to understand which elements are being used to appeal to young people.

relationship between alcopop consumption, drinking patterns and negative consequences. Their review found nine articles from three countries: six from the UK, two from Switzerland and one from Sweden. All of the studies reviewed were either cohort, case-control or cross-sectional studies.

Overall, their review found **scarce evidence to draw conclusions of a relationship between alcopop consumption and increased alcohol use, heavy episodic drinking, and negative alcohol-related consequences**. The review found three studies that showed positive correlations between alcopop consumption among youths (11-17 years) and heavy drinking; one study that provided evidence of a potential link between the consumption of alcopops and cigarettes and illegal drugs (a survey of 11-16 year old students in five English schools); and three studies that showed evidence of alcopop consumption being correlated with other risky, antisocial and aggressive behaviours (e.g. physical conflicts, accidents, risky or regretful sexual intercourse, etc.). However, none of the studies controlled for other forms of alcohol consumption leading the authors to conclude that evidence for any association between alcopops and increased risk of alcohol-related harm was misleading, given that the reviewed studies failed to provide evidence that alcopops increase certain risks above and beyond the known effects of total alcohol consumption. The authors also cited five other studies that contradicted the claim that alcopop drinkers were more likely to drink more alcohol, more often.

A study in Switzerland (Wicki, 2006) using self-reported data further supports these findings. Using a cross-sectional nationally representative sample of 5,444 drinkers aged 13-16 years old, they found that earlier initiation of consumption, more frequent risk single occasion drinking, and a higher likelihood of negative consequences for consumers of alcopops were due mainly to higher overall alcohol consumption rather than the consumption of alcopops specifically.

In contrast, the grey literature reported mixed results for the impact of alcopops on alcohol-related harm. Using ESPAD[26] data across a wide range of European countries, Anderson, Suhrcke and Brookes (2012) concluded that alcopop consumption is not disproportionately associated with binge drinking. However, using older data, Anderson & Baumberg's (2006) review of the literature concluded that studies of young people's attitudes and behaviour in several countries have reported that the consumption of alcopops and other designer alcoholic drinks[28] tended to be in less controlled circumstances and was therefore associated with heavier alcohol intake and greater drunkenness (Hughes et al. 1997, referenced in Anderson & Baumberg 2006). They also argued that alcopops contribute to lowering the age of onset of drinking (Anderson & Baumberg 2006).

[28] Designer drinks are characterised by brightly coloured and innovative packaging, while delivering the product benefits of strength, flavour and portability, for example bottled ciders and fortified fruit wines.

3.1.7 Research questions 7: What is the role played by artificial sweeteners in general and by LCS beverages in particular in developing a preference for the sugary taste and what behavioural and health consequences could there be?

Summary

- Limited peer-reviewed evidence from the US suggests that individuals prefer consuming SSBs over ASBs due to a perceived sweeter taste. However, when consumed, non-caloric sweeteners may lead to subtle changes in eating behaviours which increase calorie consumption over the longer-term.
- Looking at wider health consequences of consuming artificial sweeteners and LCS beverages, there is persuasive evidence that consumption of non-caloric artificial sweeteners can lead to glucose intolerance by altering intestinal microbiota and limited evidence that maternal consumption of ASBs during pregnancy may influence infant BMI. However studies focussing on links between consumption of artificial sweeteners or LCS beverages and type 2 diabetes, cancer and coronary heart disease were inconclusive or showed no relationship.

Data regarding cognitive, behavioural, and health consequences of consuming LCS beverages remain sparse. A number of individual studies are described below that explored a range of potential cognitive and health consequences associated with the consumption of LCS beverages. Studies used a range of terms when referring to LCS beverages including ASBs and NNS (as described in the introduction). To ensure that findings are reported accurately, findings are presented using the terminology used by each individual study.

Potential impact of LCS beverages on diet preferences and dietary behaviour

The following findings were identified in relation to how LCS beverage consumption may impact broader dietary patterns. However both studies focus on university students in the US meaning their wider applicability across European populations is unclear:

- **There is limited evidence that individuals prefer drinking SSBs over ASBs because they are perceived as significantly sweeter.** Delogu et al.'s (2016) experimental study (N = 55 U.S. university students) found that participants had difficulty recognising the type of sweetener contained in SSBs or ASB beverages[29] with only 57% accuracy and higher accuracy for beverages containing aspartame (66%) than for beverages containing sugar (52%). Male participants perceived SSBs as sweeter than female participants. Given the poor detectability of sugar and a systematic preference for drinks containing sugar, the authors concluded that preference for SSBs over ASBs might be activated by metabolic factors that are independent of conscious and rational consumers' choices.
- **Consumption of non-caloric sweeteners has been linked to subtle changes in eating behaviours which may, over time, lead to increases in calorie consumption**. Hill et al. (2014) examined consumption of non-caloric sweeteners in relation to individuals' thoughts, choices, and responses to food. The authors randomly assigned 115 undergraduate students to consume a SSB, an unsweetened beverage, or a beverage sweetened with a non-caloric

[29] All of the ASBs used in the study were sweetened with aspartame, as either the sole sweetener or in combination with other artificial non-caloric sweeteners. Beverages in the sugar sweetened category were sweetened with sugar (i.e. High Fructose Corn Syrup).

sweetener and measured participants' cognition, product choice, and subjective responses to a sugar sweetened food. The authors noted that the effects of non-caloric sweeteners on energy balance are likely nuanced, producing subtle changes in the ways that consumers think about and respond to food, making their impact on energy balance only apparent over time.

Potential health consequences of consuming LCS beverages and artificial sweeteners

There is **persuasive evidence that commonly-used non-caloric artificial sweeteners can lead to glucose intolerance** in humans by changing the composition and function of intestinal microbiota (Suez et al. 2014; Suez et al. 2015).

One peer-reviewed Canadian study also provided evidence that **maternal consumption of artificial sweeteners during pregnancy may influence infant BMI.** Azad et al. (2016) explored consumption of ASBs by pregnant women and body mass of their infants using data from the Canadian Healthy Infant Longitudinal Development (CHILD) Study, a population-based birth cohort from 2009 to 2012 including 3,023 women-infant dyads. (N=3,033 pregnant mothers and 2,686 children with BMI measurement at follow-up). Women completed dietary assessments during pregnancy, and their infants' BMI was measured at 1 year of age. The study found that daily consumption of ASBs was associated with a 0.20-unit increase in infant BMI z-score and a 2-fold higher risk of infant overweight at 1 year of age. These effects were not explained by maternal BMI, diet quality, total energy intake, or other obesity risk factors. There were no comparable associations for SSBs.

However, **other peer reviewed studies looking at the link between LCS beverage consumption and other health consequences reported less conclusive results.** One study (Sylvetsky et al. 2016) examined artificial, non-nutritive sweeteners (sucralose and acesulfame-potassium) consumption and their relationship with blood glucose, insulin, and related markers and self-reported satiety. After random assignment, 30 subjects consumed water with varying quantities of sucralose, and 31 subjects consumed diet sodas and seltzer water (355 mL caffeine-free Diet Rite Cola™, Diet Mountain Dew™ (18 mg sucralose, 18 mg acesulfame-potassium, 57 mg aspartame), and seltzer water with NNS (68 mg sucralose and 41 mg acesulfame-potassium, equivalent to Diet Rite Cola™)) in randomised order. The two diet sodas were found to be associated with a rise in GLP-1[30], however seltzer water did not produce the same result. Insulin concentrations were nominally higher following all LCS conditions but the clinical importance of this is as yet unknown. Satiety ratings, rates of gastric emptying, and intestinal glucose did not vary across test conditions.

Furthermore, one large, prospective cohort study found no relationship between LCS beverage consumption and incidence of coronary heart disease or any related biomarkers. De Koning (2012) examined data from the Health Professionals Follow-Up Study including a sample of 42,883 Canadian men. No evidence was found to suggest that overall consumption of LCSs was associated with CHD risk or changes in biomarkers; however, noncarbonated LCS beverages were associated with increased risk in an analysis of continuous intake. Similarly, no conclusive evidence was found in a systematic review by Mishra et al. (2015) looking for associations between artificial sweetener consumption and cancer among 599,741 participants. Finally, while Imamura (2015) found a positive association between ASB consumption and markers for type 2 diabetes, they indicated that the data were likely biased.

[30] GLP-1 is a hormone that induces the pancreas to release insulin in response to rising glucose while suppressing glucagon (raises concentration of glucose in bloodstream) secretion. GLP-1 is increasingly implicated in appetite regulation.

4 Conclusion

The following conclusions are based on the 60 peer reviewed and 49 grey literature references identified in this comprehensive review. Data gaps identified and potential areas for further research have been reported alongside key findings.

SSBs

- European regions were identified as having relatively low SSB consumption levels compared to the rest of the world and in most European countries, SSB consumption appears to have been in decline since 2010, although the decline has partly been offset by increases in energy drink sales. However variation exists within Europe: SSB consumption was highest in Western Europe with particularly high levels reported in the Netherlands and Belgium.
- In general, males and children and adolescents consume the highest quantities of SSBs, and, in high income countries, SSB consumption was found to be negatively associated with SES. A number of individual, interpersonal and environmental drivers for consumption were identified including certain parenting behaviours and parental characteristics, screen time and snack consumption, consumption of SSBs during childhood, obesity, stress, seasonality, proximity to fast food/convenience stores, and price discounting, marketing and advertising of SSBs.
- There is strong and consistent evidence to suggest that SSB consumption leads to increased weight status, BMI and/or body fat in both children and adults. SSB consumption has also been linked to tooth decay, obesity-related health problems and nutrient deficiencies.

Fruit juice

- Within Europe, highest average fruit juice consumption was identified in Germany, Finland, Austria, the Netherlands and Slovenia. However, the review would benefit from more studies to support these findings. More generally, high country income and being male were associated with higher fruit juice consumption and in some developed nations there is evidence that fruit juice consumption is negatively correlated with age. Seasonality, mothers' fruit juice consumption and mothers' SES were identified as drivers for fruit juice consumption, however this review would benefit from more data to confirm these findings.
- No evidence was found to support a positive association between fruit juice consumption and weight/BMI. There is currently a lack of randomised controlled clinical trials on this topic to support a causal relationship: more research is required in this area.

LCS beverages

- Most available data on LCS beverage consumption comes from the US. Findings report an increase in LCS beverage consumption over the last 20 years; a trend that is expected to continue worldwide. However, there is a need for comparative European-wide studies on this topic to better identify consumption levels and trends within Europe.
- The literature suggests that females are more likely to consume LCS beverages than males. There was also limited evidence of a positive association between LCS beverage consumption and SES and between LCS beverage consumption and age, although varying age patterns were identified. Limited evidence suggests that obese individuals may be more likely to consume LCS beverages and that seasonality may affect beverage consumption. However, more research on consumption patterns and drivers is required.

- There is no conclusive evidence that consumption of LCS beverages is associated with changes in body weight or body fat. However there is some evidence that *replacing* SSBs with LCS beverages can reduce existing body fat.
- Looking at broader behavioural and health impacts, consumption of non-caloric sweeteners has been linked to subtle changes in eating behaviours which may increase longer-term calorie consumption. There is persuasive evidence that consumption of non-caloric artificial sweeteners can lead to glucose intolerance and maternal consumption of LCS beverages during pregnancy has been linked to increased infant BMI. However, no persuasive evidence was found for a link between LCS beverage consumption, type 2 diabetes, cancer or coronary heart disease. Further research on the impact of artificial sweeteners on behaviour and health is beyond the scope of this review, however given increases in LCS consumption and the wide variety of artificial sweeteners used by drinks manufacturers, further research and assessment on this topic is essential.

Alcopops

- Alcopop consumption was found to be highest among adolescents and young adults, although in Europe, with the exception of Lichtensetein, they were not the most popular alcoholic drink among adolescents. Young girls were identified as more likely to consume alcopops than young boys and there is tentative evidence that alcopop consumption may be associated with SES and parental education. Targeted marketing and the sweet taste of alcopops were identified as drivers for consumption among adolescents. However evidence in this review was limited to grey literature and could benefit from more peer reviewed studies.
- At present, there is not enough evidence to support a relationship between alcopop consumption and increased alcohol use, heavy episodic drinking and negative alcohol-related consequences. More studies are required that control for other forms of alcohol consumption.

ANNEXES

Annex 1 Peer reviewed literature review methodology

This sub-section describes the approach taken between March 2016 and January 2018 to gather and synthesise the evidence.

A1.1 Research questions for this review

In this comprehensive review, current literature was gathered and synthesised to address objective B2. This literature review provides a review of relevant, recent studies using the methodology presented below to summarise this topic. While the methods to conduct this comprehensive literature review are systematic it is not a systematic review. Note that unlike a systematic review, this review does not systematically analyse literature to identify *all* relevant published data and/or appraise its quality.

To explore the topic objective B2, the literature review was conducted around the following agreed upon questions[31].

- Who consumes SSBs, how much do they consume and what are the drivers behind such choices?
- Who consumes fruit juices, how much do they consume and what are the drivers behind such choices?
- Who consumes LCS beverages, how much do they consume and what are the drivers behind such choices?
- What are the consequences of such consumption on overweight and obesity?
- Who consumes sweetened alcoholic beverages (artificially or sugar-sweetened), namely alcopops and sweetened spirit drinks that are pre-mixed, how much do they consume and what are the drivers behind such choices?
- What are the consequences of such consumption on alcohol-related harm?
- What is the role played by artificial sweeteners in general and by LCS beverages in particular in developing a preference for the sugary taste and what behavioural and health consequences could there be?

The findings from the eighth research question (mentioned below) are included in Objective A2, as an overarching objective area report on existing policies in the broader thematic area of nutrition and physical activity:

- What policies are more effective and efficient in this area (information, advertising, taxation, reformulation, regulations, partnerships, etc.)?

The methodology for the peer-reviewed literature is described in brief below, with greater detail on search terms provided in other Annexes.

A1.2 Peer-Reviewed Literature

Methods to conduct the literature review consisted of five steps: (1) refining the research questions, (2) developing a search approach and databases, (3) conducting literature searches (Stage 1 below), (4) screening articles for inclusion (Stage 2 below); and (5) abstracting and synthesizing relevant data (Stage 3 below).

In step 1, in partnership with DG SANTE the research questions above were confirmed. In step 2, the 3 stage approach noted below and databases were confirmed. To minimise bias, the literature search approach included identification of a priori search parameters (also considered first level inclusion and exclusion criteria) to

[31] Questions one, two, three and five were originally a single question but have been separated in this review to allow for a more comprehensive analysis. Peer-review searches were undertaken on the basis of four of the five original research questions - Peer review searches for question five were undertaken separately as part of Objective A2..

guide searches and inform screening and selection processes for data inclusion. Steps 3, 4 and 5 followed the process below:

- Conduct searches and document results (Stage 1)
- Screening search results (title and abstract) for relevance (Stage 2)
- Review full publication and abstract key characteristics and study findings (Stage 3)

Searches were conducted in multiple databases and screened following the procedures below.

Following the literature review pilot, it was agreed to merge Stages 1 and 2.

A1.3 Stage 1: Conduct Searches and Document Results

In Stage 1, searches were conducted using search terms and criteria agreed with DG SANTE, with filters set for databases to ensure accurate inclusion and exclusion of literature, as shown in tables below. The search terms used were specific to each of the five research questions. Literature searches were conducted in PubMed, EBSCO (CINAHL, ERIC, PsycInfo) and Embase. Searches included publications with all availability types (i.e. free full text and pay/subscription access).

Table 1. Inclusion and Exclusion Criteria Applied at Stage 1

Set Database Filter to Include:	Set Database filters to exclude:
1. Published between 1/1/2005-5/31/2016	2. Articles published before 1/1/2005
3. Peer-reviewed scientific publications 1. Original research 2. Systematic reviews 3. Meta-analyses	4. Editorial comments/commentaries 5. Dissertations 6. Theses 7. Opinion articles
8. Article published in English, French, German, Italian Polish and/or Spanish	Article not published in English, French, German, Italian Polish and/or Spanish

In addition to reviewing studies in databases noted above, in order to help ensure inclusion of high quality literature (e.g., literature having gone through more formal quality assessments) systematic reviews and meta-analyses were reviewed for inclusion in the literature review. Searches for systematic reviews were conducted in Cochrane Review and healthevidence.org.

As noted a separate search was carried out for each research question, resulting in five groups of publications for screening for B2. After the searches, the results were reviewed to ensure they accurately met search parameters and duplicates were removed for screening in Stage 2.

A1.4 Stage 2: Screening search results (title and abstract) for relevance

At stage 2, two screening levels were used: level 1 quality check and level 2 screening. Stage 2 screenings were done simultaneously. These screening inclusion and exclusion criteria are shown below.

A1.4.1 Stage 2 Level 1 Initial Screening (Quality check)

Search hits from all databases searched in Stage 1 were grouped by the five research questions and search terms to which they were related. Duplicate hits were deleted, and search hits by research question were organised from the most recent publications in 2016 going back in time to 2005, saved in an Excel file for that specific research question, and provided to reviewers for screening. These date parameters were agreed with DG SANTE as part of the pragmatic approach to managing the review material.

Using screening criteria in Table 1 reviewers screened the title and abstract of up to the first 200 hits per research question in each Excel file to identify literature to move forward for review. This was done to ensure the screening process was manageable given project timelines yet captured the most recent and relevant literature.[32]

A1.4.2 Stage 2 Level 2 Subsequent Screening

Simultaneous with the Level 1 initial screening check, more detailed overall inclusion and exclusion criteria were applied by the reviewers to the title and abstract to screen publications. These criteria are shown in Table 3 below under Level 2.

Table 2. Stage 2 Inclusion/Exclusion Criteria: Levels 1 and 2 Screening

Stage 2 – Level 1		
Category	**Inclusion Criteria**	**Exclusion Criteria**
Date	Published between 1/1/2005-5/31/2016[33]	Articles published before 1/1/2005
Publication Type	Peer-reviewed scientific publications Original research Systematic reviews Meta-analyses	Editorial comments/commentaries Dissertations Theses Opinion articles Non-academic journal
Language	Article published in English, French, German, Italian Polish and/or Spanish	Articles in all other languages

Table 3. Overall screening criteria for stage 2

Stage 2 – Level 2		
Category	**Inclusion Criteria**	**Exclusion Criteria**
Geography	Studies conducted in America, Australia, Canada, European Countries, Great Britain, Mexico or Brazil	Studies in all other countries

[32] Results for each research question were screened separately, however, as screening took place, team members considered if articles might be relevant to other research questions, and if so, coded the article as such.

[33] During screening, publications prior to 2005, and publications such as commentaries, dissertations or editorials were screened out, as were publications focusing on animals (rather than humans). Also note that ad hoc searches conducted post screening to supplement screened literature could have include literature post 2016.

Stage 2 – Level 2		
Human subject	Human-focused research	Animal-focused research
Behaviour/ Outcome	Studies specific to SSBs, ASBs, 100% fruit juice or sweetened alcoholic beverages Studies that address consumption of at least one of the following: - SSBs - Fruit juice - Artificial sweeteners - Alcopops - Association between weight/BMI and SSB and/or fruit juice Studies that examine the social, economic or environmental drivers of beverage consumption (SSBs, fruit juice, ASBs or alcopops) Studies that examine relationships between SSBs, fruit juice or sweetened alcoholic beverages and overweight/obesity Studies that examine relationships between ASB consumption and preference for sweet taste or other health outcomes	Studies specific to the *assessment* of methods for measuring of behaviors contributing to energy balance (e.g., assessing the validity of self-reported physical activity or dietary behaviors, methods for assessing dietary or physical activity behaviors) *OR* Specific to methods for assessing outcomes (e.g., measure of obesity) Studies specific to HFCS Studies specific to cellular metabolism as the unit of analysis Studies that examine potential individual-level drivers of consumption Studies that examine relationships between SSBs or fruit juice and other health or behavioral outcomes Studies that examine relationships between other beverages and preference for sweet taste or other health outcomes
Population	Studies where the population of focus includes children, adults or older adults in the general population	Studies where the population of focus is a special population such as critically ill, hospitalized patients, people with a chronic condition or terminal illness, those incarcerated, etc.
Measure	Studies that examine the association of behavior with weight status or BMI	Studies that examine the association of behavior with metabolic indicators (adiponectin, ghrelin, LDL, etc.), environment or genetics

From 1,000 publications screened in stage 2, 75 publications were deemed of potential relevance, coded as "Include" and selected for full article review after stage 2 screening.

A1.4.3 Stage 3: Full Article Review and Synthesis

75 publications were exported for review of full text in this B2 literature review. After reading the full text, if the article was still deemed relevant for inclusion (based on consideration of the objective and if the article helped answer research questions), it was saved for use and reference in the bibliography. Following reading articles full text in this stage, 41 publications were selected for inclusion.

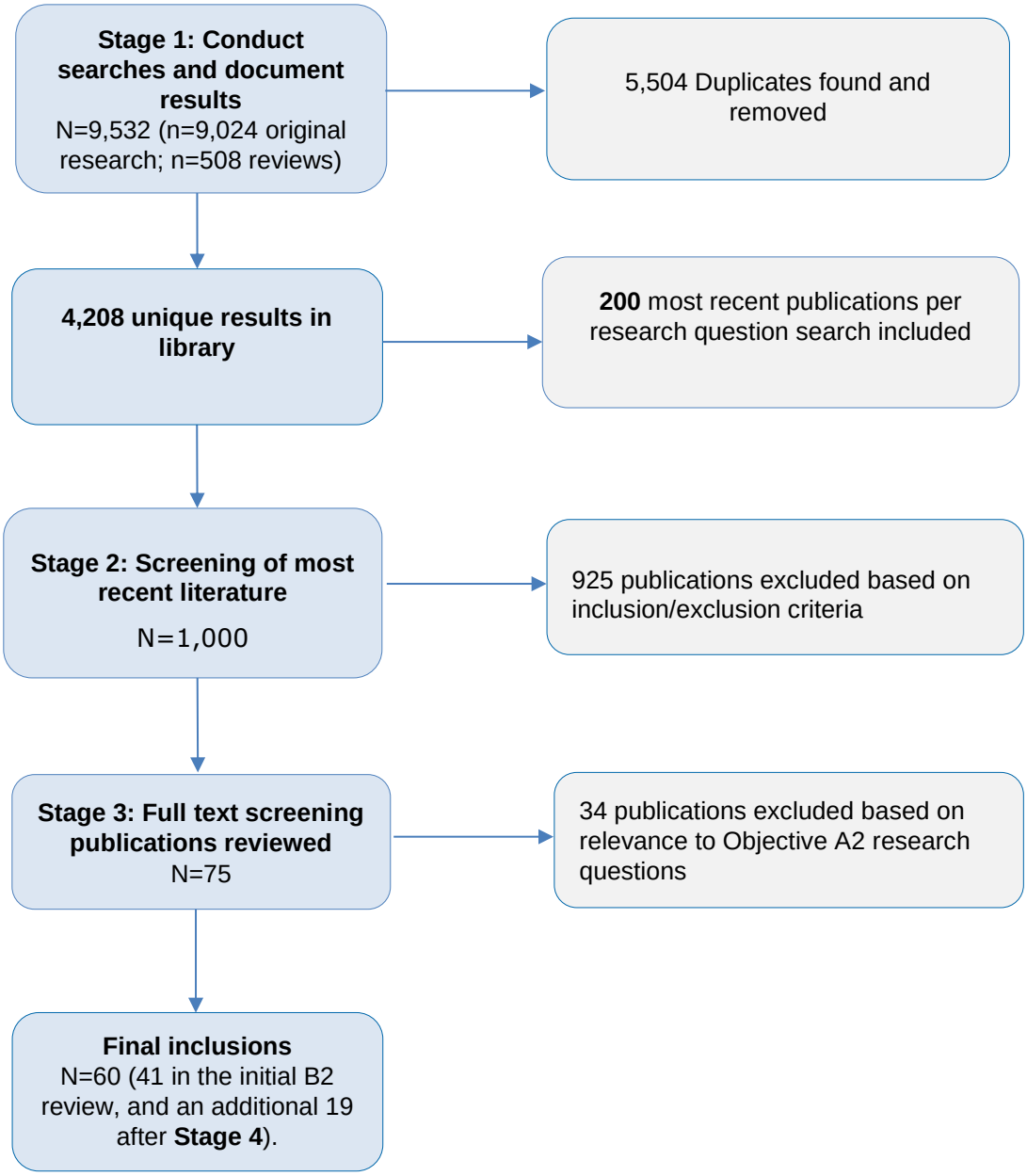
At each stage in this process, the team met to discuss successful strategies, challenges, and recommendations to improve the literature review processes. Note that although this is a comprehensive literature review and does not include a formal quality assessment process commonly conducted in systematic reviews, the team documented study designs (e.g., cross sectional, experimental) and the articles were checked by reviewers for signs of bias and poor quality research design. Further, the lead reviewer for each objective area conducted blind quality assurance checks for up to 10% of the coded articles. Any disagreements were discussed as a group and resolved with the review task lead.

A1.4.4 Stage 4: External expert reviews and input

Upon completion of the draft set of comprehensive literature reviews, subsequent to review by DG SANTE and the Joint Research Centre (JRC), expert workshops were organised to discuss findings, highlight additional relevant sources to fill gaps and improve the series of reviews. Experts were carefully selected from academic and policy-making fields, based on expertise of the specific topics addressed. As a result of this exercise, 19 additional references were screened and incorporated into these reviews.

The diagram in Figure 4 below shows the number of articles identified in peer-reviewed literature searches, and the filtering out of literature at successive stages to arrive at the final number of 60 publications whose full text was reviewed and summarised for this review. The diagram also includes additional relevant references proposed by external experts, and incorporated into this final comprehensive review.

Figure 4. Diagram showing number of included and excluded publications at each stage – peer reviewed literature



As shown in Figure 4**,** a total of 9,532 search hits were retrieved. A total of 5,504 duplicates were found and removed from the search hits resulting in 4,208 search results as data for B2. From the 4,208 articles, the team screened 200 of the most relevant and recent titles and abstracts for each research question. For B2, 1000 original research articles were screened (based on five of the original research questions). From the 1,000 most recent titles and abstracts screened 75 were deemed of potential relevance and reviewed as full texts. From the 75 deemed relevant and reviewed as full texts 41[34] publications were selected for inclusion, in this final review. Search terms for the research questions are shown in Annex 2.

[34] The full list of references included from the peer-reviewed literature can be found in Annex 3 and includes 19 publications recommend by the external expert review panel.

Annex 2 Search terms

Objective B2 Search Terms

Who consumes SSBs, fruit juices and LCS/ASBs, how much do they consume and what are the drivers behind such consumption?

Primary Term		Combined with:	
"Beverages"	[mh]	Prevalence	[tiab]
"Sweetening agents"	[mh]	Pattern*	[tiab]
Artificial-Sweetener*	[tiab]	Trend*	[tiab]
Beverage* AND (consume*OR consumption	[tiab]	Predictor*	[mh]
Juice* AND consume* OR consumption	[tiab]	"Environmental factor"	[mh]
Soda AND consume* OR consumption	[tiab]	"Environmental factors"	[tiab]
"Sugar sweetened beverage"	[tiab]	"Environment"	[tiab]
"caloric drinks"	[tiab]	"Dietary intake	[tiab]
"Sweetening agent"	[tiab]	"Social environment"	[mh]
		"Social environment"	[tiab]

Who consumes sweetened alcoholic beverages – namely alcopops and sweetened spirit drinks. How much do they consume and what are the drivers behind such consumption?

Primary Term		Combined with:	
trichlorosucrose	[Supplementary Concept]	Prevalence	[tiab]
Artificial-Sweetener*	[tiab]	Pattern*	[tiab]
low-calorie-sweetener*	[tiab]	Trend*	[tiab]
non-nutritive-sweetener*	[tiab]	Predictor*	[tiab]
"diet beverage"	[tiab]	"Environmental factor"	[tiab]
Sweet* AND alcohol*		"Environmental factors"	[tiab]
Aspartame	[tiab]	"Environment"	[tiab]
Saccharin	[tiab]	"Dietary intake"	[tiab]
Sweetening-Agent*	[tiab]	"Social environment"	[mh]
		"Social environment"	[tiab]

What are the consequences of such consumption on overweight and obesity?

Primary Term	Combined with:

"Diet soda"	[tiab]	Consequence*	[tiab]
Sucralose	[tiab]	Adverse-effect*	[tiab]
Aspartame	[mh]	"Risk factors"	[mh]
"Beverages"	[mh]	"adverse effects"	[sh]
"Sweetening agents"	[mh]	obesity	[mh]
		Metabolism	[mh]
trichlorosucrose	[Supplementary Concept]		
Saccharin	[mh]	Risk	[tiab]
Artificial-Sweetener*	[tiab]	Overweight	[tiab]
low-calorie-sweetener*	[tiab]	Obese	[tiab]
		Obesity	[tiab]
non-nutritive-sweetener*	[tiab]	Metabolism	[tiab]
"diet beverage"	[tiab]		
Sweet*AND alcohol*	[tiab]		
Aspartame	[tiab]		
Saccharin	[tiab]		
Sweetening-Agent*	[tiab]		
Beverage* AND consume* OR consumption	[tiab]		
juice* AND consume* OR consumption	[tiab]		
Soda AND consume* OR consumption	[tiab]		
"caloric drinks"	[tiab]		

What are the consequences of such consumption on alcohol related harm?

Primary Term		**Combined with:**	
Sweet* AND alcohol* beverages	[tiab]	Consequence*	[tiab]
Sweet*AND alcohol* beverage	[tiab]	Effect*	[tiab]
		Adverse-effect*	[tiab]
		"Adverse effects"	[sh]
		"Analysis"	[sh]
		"Risk factors"	[mh]
		"Health risk"	[tiab]

		Risk-factor*	[tiab]

What is the role played by artificial sweeteners in general and by artificial sweetened beverages in particular in developing preference for sugary taste and what behavioural and health consequences could there be?			
Primary Term		**Combined with:**	
"Diet soda"	[tiab]	Satiation	[tiab]
Sucralose	[tiab]	"Food preferences"	[mh]
"Sweet taste"	[tiab]	"Taste/physiology"	[mh]
"Beverages"	[mh]	"Satiation/physiology"	[mh]
"Sweetening agents"	[mh]		
"Alcoholic beverages"	[mh]		
Aspartame	[mh]		
trichlorosucrose	[Supplementary Concept]		
Saccharin	[mh]		
Artificial-Sweetener*	[tiab]		
Sweetening-agent*	[tiab]		
low-calorie-sweetener*	[tiab]		
non-nutritive-sweetener*	[tiab]		
diet-beverage*	[tiab]		
Sweet* AND alcohol*			
Aspartame	[tiab]		
Saccharin	[tiab]		
Beverage* AND consume* OR consumption	[tiab]		
Soda AND consume* OR consumption	[tiab]		
"Caloric drinks"	[tiab]		
juice* consume* OR consumption	[tiab]		

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Annex 4 Grey literature review

This sub-section describes the approach taken between March 2016 and January 2018 to gather and synthesise the evidence.

A4.1 Detailed search and review methodology

The review followed a process with five main stages:

- Searching for publications using set keywords and databases;
- Screening of search results for relevance;
- Screen results against inclusion/exclusion criteria, quality and relevance;
- Extraction of full texts and final screening process; and
- External expert reviews and input.

A4.2 Stage 1: Conducting searches and documenting results

A4.2.1 Searching for grey literature

The search terms initially used for objective B2 were agreed upon in the inception phase (Table 4). The main key words were either specific to the objective or broader thematic terms. A second list of search terms was also used – these combination words were used to guide the search and produce the most relevant results.

Table 4. Search terms used for objective B2 grey literature review

Suggested Search Parameters	
Parameters	
• Grey literature • Published in English, French, German, Italian, Polish and/or Spanish • Date range (1995 – 2017)	
Key Words and Suggested Combinations of Search Terms	
Key Words	**Combined With**
Fruit juices	Food trends
Alcoholic sugar sweetened beverages	Beverage Trends
Sugar sweetened beverages	Consumption practices
Alco-pops	Meal patterns
Sweetened spirits drinks	Media campaigns
Artificially sweetened beverages	Food marketing
Alcoholic beverages	Advertising
Alcohol consumption	Taste preferences
Alcohol related harm	Reformulation
Soda tax	Regulation
Sugar tax	Prevention programs (programmes)
Sugar sweetened beverage policy	Prevention policies
	Policy evaluations
	Policy monitoring

	Member States (of the EU) / Country (Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, The Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom)

A4.2.2 Using set key words in databases, search engines and websites

In order to appropriately link and define the relationship between the key and combination search terms, the Boolean operators 'AND', 'NOT' and 'OR' were used in the search engines. In particular, the use of 'AND' helped to narrow the number of hits to ensure that only documents which included all the search terms showed up. Further, if a search led to a high number of irrelevant hits, a repeat search was conducted and key words which were separated by spaces or other characters (e.g. Health impacts) were enclosed in quotation marks (e.g. "health impacts") to return only those documents that matched the search terms exactly.

The set key words and combination words were used to generate results in databases, search engines and websites recommend by the pilot review:

- Search Europa
- European Sources
- Eurostat
- NICE
- Open grey
- WHO websites

Search Europa and NICE Evidence Database yielded the most results for objective B2.

The grey literature review was a dynamic and fluid process. After the initial searches and extraction of sources, hand searching on Google was used to produce specifically relevant results. This is described further in the section below.

A4.2.3 Additional hand searching

As per the recommendation made in the pilot review, hand searching was also used to supplement the key word searches. Hand searching involved extending the basic key word searches by using additional, contextual information. This process ensured that highly-focused and relevant search results were generated for the original key words. All hand searches for this objective were completed on Google.

A4.3 Stage 2: Screen Search Results for Relevance

Most databases, search engines and websites offered the use of a relevancy filter[35] which automatically sorts results in order of their applicability to the key terms in the search engine. When a relevancy filter was not available, the links were manually screened by the appearance of the key search terms in the title of the source and the

[35] 'Sorting by relevance' on databases and search engines enables a connection to be established between the information in the database, the search string entered and any search filters chosen. If the keywords appear in a Title or Author field, the system shows these results first in the list of search returns. Less relevant articles e.g. ones where the keyword appears less often or may only appear in the actual content, appear later in the list of search results.

abstract (where available). For database and search engines, initially the top 50 most relevant search results were looked at per search string. If there were less than 50 results, all were looked at. The titles and abstracts were then examined for key search terms in the grey literature and relevance to the research questions.

Extra hand searching was conducted when search strings did not produce enough relevant information, and/or, when the top 50 results did not produce the most relevant literature. Hand searching involved extending the basic key word searches by using additional, contextual information.
Following the expert workshop (see stage 5 below), experts recommend further sources which were reviewed in the final redraft of the review.

Overall 167 results from the searching for objective B2 were saved into a library.

A4.4 Stage 3: Screen results against inclusion/exclusion criteria, quality and relevance

Results were then screened against agreed inclusion and exclusion criteria detailed in Table 5 below.

Table 5. Grey literature inclusion and exclusion criteria

Inclusion	Exclusion
Published between 2005-2017	Published or enacted prior to 2005
Government reports from European Commission, European Parliament and EU Member States.	Non-nutrition and physical activity themed/focused
Think tank reports/publications	Industry-produced publications
Academic papers, conference papers and abstracts	Industry-produced project evaluation reports
Bibliographies	Industry-produced good practice reports
Programme evaluation reports[36]	Publications focusing on animal nutrition and physical activity
Standard/best practices documents	Blog or personal think thought pieces
Policy initiatives at European and/or national level- run by governments, not-for profit organisations	Newsletters or news articles
Industry funded publications (As regards the grey literature reviews, particular care will be exerted in assessing any inclusion of industry-funded literature. These will be justified and discussed with the client).	Theses and dissertations (2010 and older)
Primary theme/focus is human nutrition and physical activity	

[36] For example: Hallsworth M, Ling T. (2007) *The EU platform on diet, physical activity, and health: second monitoring progress report. Cambridge: RAND Corporation*, http://www.rand.org/content/dam/rand/pubs/technical_reports/2008/RAND_TR609.pdf

Inclusion	Exclusion
Publication available via accessible databases	
Published in English, French, German, Italian, Polish and/or Spanish	
Theses and dissertations (post-2010 only)	

Due to the large number of results still returned after this screening the data parameters were further refined to only include those reports published 2005-2017.

Following this criteria screening and exclusion of search results, the remaining results were checked for quality and relevance.

A4.4.1 Exclusion based on quality checklist

The quality check was based on the AACODS checklist (AACODS)[37] which included:

- Authority
  - Is the author credible?
- Accuracy
  - Is the document supported by documented and authoritative references?
  - Is there a clearly stated methodology?
  - Is the document representative of work in the field?
- Coverage
  - Have limitations been imposed and are they clearly stated?
- Objectivity
  - Can bias be detected (if so the bias was clearly stated in the extraction form)?
- Date
  - Does the document have a clearly stated date relating to the content?
- Significance
  - Is the document relevant?
  - Would the document enrich the findings?

A4.4.2 Exclusion based on relevance to research questions

The remaining grey literature was examined further so that only results most relevant to the objective were extracted. In particular, each article was examined for text relating to the key terms and questions under the objective. In total 87 results were excluded during this screening process; 80 results were extracted.

A4.5 Stage 4: Extraction of full texts and final screening process

A data extraction template in Excel was used to capture the following categories of information: 1) identifying information for each publication, 2) study design

[37] Please see the full outline of the AACODS checklist here: https://dspace.flinders.edu.au/jspui/bitstream/2328/3326/4/AACODS_Checklist.pdf

characteristics, 3) sample characteristics, 4) intervention characteristics, 5) content (behaviour/outcome) focus, 6) description of results, 7) assessment of rigour/bias and 8) objective specific information.

After extraction, the review author read through all of the extracted data and a final screening process excluded more results due to quality or a lack of enough relevant information, now made obvious after extraction. Sources were also excluded from the grey literature where this was superseded by either more rigorous peer reviewed research on the same theme, or more recent statistics. In total, 40 references were extracted.

A thematic analysis was applied to the remaining extracted data and their findings synthesised with those of the peer reviewed literature. Any identified bias in sources which passed the inclusion criteria is highlighted in the analysis.

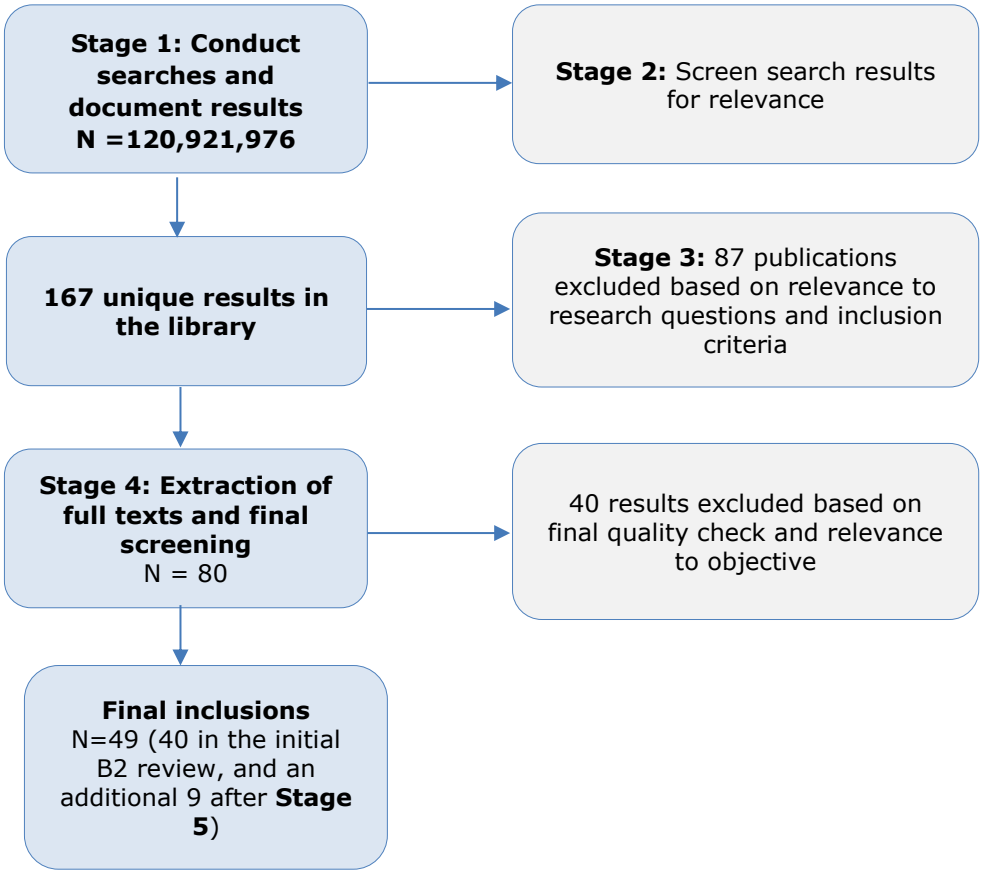
A4.6 Stage 5: External expert reviews and input

Upon completion of the draft set of comprehensive literature reviews, expert workshops were organised to discuss findings, highlight additional relevant sources to fill gaps and improve the series of reviews. Experts were carefully selected from academic and policy-making fields, based on expertise of the specific topics addressed. As a result of this exercise, nine additional references were screened and incorporated into these reviews.

A4.7 Number of included and excluded references

The diagram in Figure 5 below shows the number of articles identified in grey literature searches, and the filtering out of literature at successive stages to arrive at the final number of 40 publications whose full text was reviewed and summarised for this review. The diagram also includes additional relevant references proposed by external experts, and incorporated into this final comprehensive review.

Figure 5. Diagram showing number of included and excluded grey literature publications at each stage



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