



Reviews of Scientific Evidence and Policies on Nutrition and Physical Activity

Objective Area A1: Behaviours Contributing to
Positive Energy Balance



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Reviews of Scientific Evidence and Policies on Nutrition and Physical Activity

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Positive Energy Balance

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Contents

Contents	v
Preface.....	1
About this project	1
About this series	1
Approach and purpose.....	1
Glossary	3
Objective A1: Behaviours Contributing to Positive Energy Balance	6
1 Introduction	6
1.1 Scope of this review	7
1.2 Research questions for this review	8
2 Methodology	9
2.1 Peer review method.....	9
2.2 Grey literature method.....	9
3 Findings and discussion	11
3.1 Research Question 1: What behaviours contribute to positive energy balance?	11
3.2 Research Question 2: What are the main drivers for food shopping, cooking, eating and physical activity choices?.....	14
3.3 Research Question 3: How can these behaviours/choices be nudged so as to become healthier?.....	24
4 Conclusion	34
Annex 1 Peer-reviewed literature review methodology	36
A1.1 Research questions for this review	36
A1.2 Peer-Reviewed Literature	36
Annex 2 Peer-reviewed literature search terms.....	42
Annex 3 Peer reviewed literature bibliography	48
Annex 4 Grey Literature review methodology	52
A4.1 Detailed search and review methodology.....	52
A4.2 Stage 1: Conducting searches and documenting results	52
A4.3 Stage 2: Screen Search Results for Relevance	54
A4.4 Stage 3: Screen results against inclusion/exclusion criteria, quality and relevance	55
A4.5 Stage 4: Extraction of full texts.....	56
A4.7 Stage 6: External expert reviews and input	57
A4.8 Number of included and excluded references	57
A4.9 Grey literature bibliography	58

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; Children aged 5-19 overweight is BMI-for-age	WHO http://www.who.int/mediacentre/factsheets/fs311/en/ (Other definitions are available for different national and international systems).

Term	Definition	Source
	greater than 2 standard deviation above the WHO Growth Reference median.	
Child/adolescent overweight	<p>There are different systems available to measure child or adolescent overweight for different ages.</p> <p>Children under 5 overweight is weight-for-height greater than 2 standard deviations above WHO Child Growth Standards median;</p> <p>Children aged 5-19 overweight is BMI-for-age greater than 1 standard deviation above the WHO Growth Reference median.</p>	<p>WHO</p> <p>http://www.who.int/mediacentre/factsheets/fs311/en/</p> <p>(Other definitions are available for different national and international systems).</p>
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.	<p>WHO</p> <p>(http://www.who.int/dietphysicalactivity/pa/en/)</p>
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.	<p>WHO</p> <p>http://www.who.int/mediacentre/factsheets/fs385/en/</p>
Physical activity	Any bodily movement produced by skeletal muscles that requires energy expenditure.	<p>WHO</p> <p>(http://www.who.int/topics/physical_activity/en/)</p>
Physical inactivity	A lack of physical activity	<p>WHO</p> <p>(http://www.who.int/diet</p>

Term	Definition	Source
Sedentary behaviour	Any waking behaviour characterized by an energy expenditure ≤ 1.5 metabolic equivalents (METs) while in a sitting or reclining posture.	physicalactivity/pa/en/ Tremblay, M. S., et al. (2017). Sedentary Behavior Research Network (SBRN) – Terminology Consensus Project process and outcome. <i>The International Journal of Behavioral Nutrition and Physical Activity</i> , 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. <i>US Department of Health and Human Services. Dietary guidelines for Americans, 2010</i> . 7th edition, Washington (DC): US Government Printing Office

Objective A1: Behaviours Contributing to Positive Energy Balance

This comprehensive review describes the scientific evidence of behaviours contributing to positive energy balance as well as the factors influencing such behaviours (e.g., motivations, taste and eating preferences).

This report synthesizes the findings of reviews of the peer-reviewed and grey literature on this topic. It has four sections:

- Introduction, describing the relevance of this topic, the scope of the reviews, and the principal research questions;
- Methodology, describing how the reviews were undertaken and relevant findings extracted;
- Findings from the peer-reviewed and grey literature, presented according to each research question; and
- Conclusions drawn from the reviews overall and an assessment of the current scientific evidence, including any gaps in the knowledge.

1 Introduction

Overweight and obesity are currently at epidemic proportions (Finucane et al., 2011). As the obesity epidemic has emerged, researchers and health care professionals have developed a variety of hypotheses to explain the cause. Many hypotheses consider the cause to be either excessive caloric intake or insufficient calorie expenditure. However, one leading hypothesis argues that the explanation is better constructed in terms of energy balance, i.e., a lack of energy balance, which in turn, increases risks for obesity (Hill et al. 2012). The energy balance model of obesity identifies that weight gain and in-turn overweight/obesity are the result of positive energy balance, i.e., calories taken in exceed the number of calories expended¹ (Hill et al., 2012). Using the energy balance model as a framework, obesity prevention can be targeted by enabling strategies to improve both dietary and physical activity behaviours (Hill et al., 2012; Lutes et al., 2008; Stroebele et al., 2008). Further, strategies based in the energy balance framework coupled with the use of small, manageable changes show evidence of creating sustained behaviour change and prevention of weight gain (Arno & Thomas, 2016; Lutes et al., 2008; Stroebele et al., 2008; Rodearmel et al., 2007). These findings suggest that strategies grounded in the concepts of energy balance and focused on small changes may hold promise for large-scale obesity prevention efforts.

Energy Balance

Definition:
Calories consumed = calories expended

Positive Energy Balance:
Calories consumed > calories expended
*Results in weight gain

Negative Energy Balance:
Calories consumed < calories expended
*Results in weight loss

To address energy balance and promote small changes in dietary behaviour and physical activity, it is important to understand what factors influence or drive these behaviours. Research identifies both macro and micro level contexts as driving dietary and physical activity behaviours. Bosdriesz et al., (2012) describe macro environments as those at the level of city, state or country that may influence obesity-related behaviours. These

¹ Hill et al, (2012) note, "When energy intake exceeds energy expenditure, a state of positive energy balance occurs and the consequence is an increase in body mass. Conversely, when energy expenditure exceeds energy intake, a state of negative energy balance ensues and the consequence is a loss of body mass. Any genetic or environmental factor that impacts body weight must act through one or more component of energy balance (p127)."

factors may include, for example, distribution of food stores, places for physical activity, prevalence of sidewalks, or food production policies (among others). Micro environments include the environments within a single location such as the home, school, worksite, restaurant, park, or trail.

Presently, the literature has established the role of social and cultural factors such as social support and family, and culturally embedded dietary habits as influencing dietary behaviour and physical activity (Salmon et al., 2007; Franzini et al., 2009; Haerens et al., 2008). Additionally, access to environments that offer opportunities for physical activity engagement and purchasing of healthy foods show evidence of influencing behaviours (Morland et al., 2002; Giles-Corti et al., 2003; Franzini et al., 2010). These findings suggest that macro-level elements of the food environment as well as the physical activity environment can enable or inhibit physical activity and/or healthy eating. These findings on the food and physical activity environments suggest that changes in the environment that enable healthy diet and physical activity choices may affect population-level changes.

Research has also examined how micro-level processes may influence dietary and physical activity behaviours. Eating using smaller plates (to affect actual and perceived portion sizes), identifying healthy food products via attention-grabbing labels, changing serving sizes or placing stair prompts near elevators have all demonstrated evidence of changing behaviours by focusing on the moment an individual makes a choice (Arno and Thomas, 2016; Skov et al., 2013; Kremers et al., 2012). Thaler and Sustein draw on a wide range of research in their 2008 book, *"Nudge: Improving Decisions about Health, Wealth, and Happiness."* They discuss how small changes via non-compulsory incentives (rather than stringent regulatory policy) within a micro-environment (i.e., school, workplace, grocery store, home etc.) can 'nudge' an individual or group into making a healthy choice through "choice architecture" (.

1.1 Scope of this review

The purpose and scope of this review is to examine behaviours associated with energy balance, drivers of these behaviours and the ways in which individuals may be "nudged" to make healthier choices.

It is important to note that this objective considers the influence of dietary behaviours broadly. Specific dietary behaviours such as consumption of beverages with added sugars or artificial sweeteners are the focus of objective B2. Similarly, objective B3 focuses on consumption of high fructose corn syrup and potential consequences. Objective A2 considers which policies (those strategies and/or interventions that relate to laws, regulations or voluntary practices enacted by governments and institutions)² are effective in reducing weight status and improving physical activity and so these are not considered here. However, we distinguish the larger macro-level policy context from local level micro changes such as "nudging" strategies and interventions. Nudging strategies are government enacted, non-regulatory incentives that aim to influence, choice by prompting, or "nudging" individuals toward more healthy choices and changes by altering elements of the local-level micro environment. These local-level changes that exemplify nudging can include, for example, nutrition labeling or signage in a grocery store or restaurant, placing a salad bar first in a cafeteria line, decreasing portion sizes (e.g., with smaller plates) or using stair prompts near elevators. This is considered as part of one research question, which is further described below.

² Definition of policy was based on the Centers for Disease Control and Prevention's definition <http://www.cdc.gov/stltpublichealth/Policy/>

1.2 Research questions for this review

In this review, we focus on the most current literature (peer-reviewed original research and systematic reviews, as well as grey literature) on behaviours contributing to positive energy balance. The aim of this review is to identify the factors influencing dietary behaviour and physical activity, how dietary and physical activity behaviours can become improved (i.e., healthier), and what interventions and strategies show the greatest promise for improving dietary and physical activity behaviour.

To explore the topics of energy balance and effect of micro-level nudging for the purposes of obesity prevention, the research was conducted around the following questions:

- What behaviours contribute to positive energy balance?³
- What are the main drivers for food purchasing, cooking and eating (and eating together) and physical activity choices?
- How can these choices/behaviours be efficiently framed or nudged so as to become healthier?

The findings from the third 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.)?

³ This question was added to the original list of research questions developed by DG SANTE in order to further examine the evidence about behaviours contributing to positive energy balance which were not emerging from searches. Literature searches specific to the behaviours associated with positive energy balance were conducted as part of the peer-reviewed literature only.

2 Methodology

The review is based primarily on peer reviewed literature (which is prioritised), with grey literature used to supplement any gaps (but treated with caution and the strength of the evidence assessed). For each set of literature specific search terms and inclusion and exclusion criteria were used; and quality checks undertaken. The research questions and search terms were confirmed with DG SANTE at the start of, and then refined during a review point within, the process.

After the initial searching and extraction of literature, drafts were provided to DG SANTE and the Joint Research Centre (JRC) for review. Expert workshops (with experts from relevant academic and policy-making fields) were then held to discuss findings and highlight any additional sources to fill gaps, in order to improve the series of reviews. The final outputs of the study ('the reviews' as presented here for A1) were then reviewed by a topic expert at the University of Birmingham.

While the methods to conduct this comprehensive literature review are systematic it is not a systematic review. More information on the methodology can be found in the Annexes.

2.1 Peer review method

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

A total of 19,028 search hits of peer reviewed literature were initially retrieved using selected search terms per research question. A total of 3380 duplicates were found and removed from the search hits resulting in 15,648 search results for A1. From the 15,648 articles, the team screened 600 of the most recent titles and abstracts (200 for each of the three research questions, to create a manageable amount of material within the resources for the study; and on the premise that the most recent material was most relevant science). From the 600 most recent titles and abstracts screened, 265 were deemed of potential relevance and reviewed as full texts. From the 265 deemed relevant and reviewed as full texts, 48 publications were selected for inclusion in this final review.

The full peer reviewed searching and extraction methodology is outlined in Annex 2 and Annex 3.

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, where hand searching was also utilised to find the most relevant sources.

A total of 3511035 search hits of grey literature were initially retrieved using selected search terms. As this was unmanageable a relevancy filter and the most relevant 10 per cent of records were included.⁴ A total of 335 search hits were therefore retrieved and saved for A1. From the 335 articles, the team excluded 274 based on lack of relevance to the research questions. From the 81 results saved in the library, 45 were excluded based on the inclusion/exclusion criteria, quality of evidence and relevance to the research

⁴ This is further explained in Annex 4 and differed from standard practice which was to screen most relevant 50 records per research question using a relevancy filter. This was increased to reflect the vast number of search hits.

questions. From the 36 deemed relevant and reviewed as full texts, 27 publications were selected for inclusion.

The full grey literature searching and extraction methodology is outlined in Annex 4.

3 Findings and discussion

The findings from the reviews are presented by each research question. Findings related to each research question are first summarised, and details specific to the peer-reviewed and grey literature are included in the subsections that follow.

3.1 Research Question 1: What behaviours contribute to positive energy balance?

Understanding how physical activity and nutrition behaviours contribute to preventing overweight and obesity is an important step in developing and implementing interventions that will promote energy balance. The review team identified four articles that discussed energy balance-related behaviours (EBRBs) among Europeans. All four of these studies used cross-sectional data and the majority focused on EBRBs among children or adolescents. Given these studies' research design, challenges remain in identifying clear associations between presumed causal factors (e.g., nutrition behaviours) and outcomes (e.g., measures of overweight). The findings from these studies are highlighted below. Literature searches specific to the behaviours associated to positive energy balance were conducted as part of the peer-reviewed literature review only.

- Few peer-reviewed research was found about the impact of dietary behaviour, physical activity or sedentary behaviour/screen time on positive energy balance or overweight/obesity among European populations, particularly among adults.
- Among studies with European youth, there were mixed results related to the impact of dietary behaviour, physical activity and sedentary time on positive energy balance with some evidence that associations vary by country.
- Among samples of children from Europe, time spent engaging in physical activity was associated with lower BMI and the time spent in front of a screen was associated with higher BMI.
- One peer-reviewed study of adults based in the UK found increased energy intake combined with reduced physical activity was associated with increased BMI among men but not women.
- Children of low-income/low educational attainment families may be at greater risk of positive energy balance (more calories consumed than expended) when compared with children of higher income/high educational attainment families due to poor dietary behaviours and higher amounts of sedentary/screen time.
- Data on dietary behaviour, physical activity and sedentary time from the peer-reviewed literature included in this review were gathered using a variety of methods and measures, which may have contributed to associations with BMI being mixed.

3.1.1 Summary

3.1.2 Diet and physical activity behaviours and energy balance

Three studies looked at the differences in energy balance related behaviours and the impact of these behaviours on weight. These studies found mixed results on the role of diet and physical activity and positive energy balance (Herzig et al., 2012, van Stralen et al., 2012; Scarborough et al., 2011).

Results related to the impact of dietary behaviour on positive energy balance among European youth were mixed.

A school-based cross-sectional study of children age 10-12 was conducted comparing body composition and energy-balance related behaviours between Swiss children (n=546) and seven other European "European Energy balance Research to prevent excessive weight Gain among Youth" (ENERGY) countries (Herzig, et al. 2012). Results identified that Swiss children's dietary habits were similar to children from the seven European ENERGY countries.⁵ However, prevalence of obesity among Swiss children is significantly lower compared to all European ENERGY-partners. These dietary habits (soft drink and fruit juice consumption, eating breakfast) were not attributed to the differences found in Swiss children's weight status compared to the ENERGY countries. The authors report that Swiss children are more active and less sedentary than the European ENERGY-Partners, which may explain the differences between these two school-based samples in overweight and obesity prevalence among school-age children.

Van Stralen et al. (2012) conducted a secondary analysis of six cross-sectional European datasets to examine the relationships between overweight and obesity among pre-schoolers 4-7 years of age. The authors found mixed and insufficient evidence for an association between dietary behaviours and overweight. Comparison across the studies was complicated due to the differences in measurement of overweight indices, sedentary behaviour, physical activity, and dietary behaviours. For example, some overweight indices included height, weight, or BMI only, while others included waist circumference. Sedentary behaviour was represented by a measure of TV watching, screen time, or time spent being sedentary. Physical activity (PA) was represented by a measure of total PA, sports participation, or leisure time. Some measures of dietary behaviour included "breakfast skipping" in addition to measures of fruit and vegetable intake. Apart from weight indices, all these measures were parent-reported, either by questionnaire or interview, indicating another limitation of the study. When conducting within country analyses, Van Stralen et al. reported the following associations between (parent-reported) nutrition related behaviours and energy balance:

- Soft drink intake was positively associated with BMI in the Belgian and German studies;
- Fruit juice⁶ intake was negatively associated with BMI in the Greek study;
- Water consumption was positively associated with BMI in the Belgian study;
- Watching television while eating was positively associated with BMI in the Bulgarian study, but not in the Spanish study;
- Snack intake was positively associated with BMI in the Belgian study but this was not confirmed in other studies;
- Fruit intake had a negative association with BMI in the Greek study; a positive association with BMI in the German study; and the Belgium study found no association between fruit intake and BMI; and
- Vegetable intake was positively associated with BMI in the German study; negatively associated in the Belgian study with no association found in the Greek study.

Among samples of children from Europe, associations between time spent being physically active or in front of a screen and BMI were mixed. Using a survey administered to 546 10-12 year old Swiss school children, Herzig et al. (2012) found that

⁵ The ENERGY countries are Belgium, Greece, Hungary, the Netherlands, Norway, Slovenia, and Spain

⁶ Review does not define contents of "fruit juice"

Swiss children, when compared to children from seven European ENERGY countries, on average, had higher levels of physical activity, which include:

- Walking or cycling to school: 71 min/week vs. 56 min/week and walked or biked to school more days per week (4.7 days/week vs. 3.9 days/week);
- More time engaged in sports activities per week (164 minutes/week vs. 149 minutes/ week)
- Spent fewer minutes per day watching TV (79 min/day vs 112 min/day) and engaged in computer activities (53 min/day vs 81 min/day).

These differences in physical activity levels and screen time between Swiss children and children from the European ENERGY countries were identified as a likely contributing factor to lower prevalence of overweight and obesity among Swiss children. However, overweight and obesity rates among children from non-native ethnicity⁷ were more likely to be overweight or obese, suggesting the influence of socio-economic or cultural factors in these differing prevalence between groups of Swiss children.

In their secondary analysis of six cross-sectional European datasets, van Stralen et al. (2012) found that among pre-schoolers 4-7 years of age there was:

- A significant positive association between total screen time and BMI among children in Belgium and Germany
- A significant negative association between physical activity and BMI in Bulgaria

A UK-based cross-sectional study of adults found that increased energy intake combined with reduced physical activity was associated with increased BMI among males but not females. Scarborough, et al. (2011) assessed the contributions of increased mean energy intake and decreased mean physical activity levels to body weight among adults (N=1524) aged 19-64 in the UK between 1986 and 2000. Using estimates of mean total energy intake calculated from food availability data adjusted for wastage and mean body weight, the authors examined the differences in mean body weight between the two time points. They found that the increases in mean body weight for women in the UK between 1986 and 2000 were associated with increased total energy intake. However, the increases in mean body weight among men was due to both increased total energy intake and reduced physical activity levels.

Disparities in weight and energy-balance related behaviours: SES and Education Levels

Children of low-income/low educational attainment families may be at greater risk of positive energy balance (more calories consumed than expended) when compared with children of higher income/high educational attainment families.

In Herzig, et al.'s (2012) school-based cross-sectional study of 546 Swiss children aged 10-12, children from lower SES background⁸ reported a significantly higher intake of soft-drinks per day (496 ml vs 311 ml) and spent significantly more time engaging in screen-based activities per day (150 min vs. 120 min) than children from a higher socio-economic background. In their secondary analysis of six cross-sectional European

⁷ Ethnic background was assessed by all ENERGY Partners based on the language spoken at home or on the country of origin of the parents. It was classified as 'non-native' if another language than German, French or Italian was spoken at home or one or both parents were born in a foreign country, and as 'native' if German was spoken at home or if both parents were born in Switzerland.

⁸ Herzig, et al. (2012) used parental education as a measure of SES. The variable was dichotomized into High SES/Low SES using a cut off of 12 years.

datasets⁹ to examine overweight and obesity among pre-schoolers 4-7 years of age, Van Stralen et al. (2012) found an association between low parental SES (measured by parental education level) and children's overweight.

In a cross-sectional study, Mantziki et al. (2015) examined the differences in EBRBs and explored related social and environmental determinants among a sample of 1,266 children aged 6-8 years in high and low SES groups in Belgium, Bulgaria, France, Greece, Portugal, Romania, and The Netherlands. The samples were divided into two groups based on the educational level of the mother (low and high education level). Tests of association¹⁰ were used to identify potential determinants between the two socio-economic groups and differences in self-reported behaviours. Their baseline measurements identified the following statistically significant differences across the two groups in the following EBRBs:

- Across all countries, children in the high education group consumed fruits more frequently than those in the low education; and
- Across all countries, children in the low education group (as compared to higher education groups) had a higher:
 - intake of fruit juices¹¹;
 - intake of soft drinks and frequency of soft drink intake; and
 - hours per week of total screen time.

The authors also examined the disparities in children's physical and social environmental determinants of EBRBs. Although they did not find a common pattern for all behaviours across the countries, parental rules and home availability of fruits and vegetables, fruit juice, soft drinks, and television were consistently different between the two SES groups in all countries. They identified the following differences between the high and low education group across the total sample. Parents in the low-education group were more likely to:

- Reward/comfort their child by giving fruit juices;
- Allow children to consume soft drinks/sugar-sweetened beverages;
- Drink soft drinks together with their child;
- Have the television on during meal times; and
- Allow children to have televisions in their bedroom.

3.2 Research Question 2: What are the main drivers for food shopping, cooking, eating and physical activity choices?

3.2.1 Summary

⁹ Belgium (N=1,434); Bulgaria (N=726); Germany (N=2,956); Greece (N=708); Poland (N=375); Spain (N=273)

¹⁰ Mann-Whitney U test for ordinal variables and Pearson's chi-square for binary variables

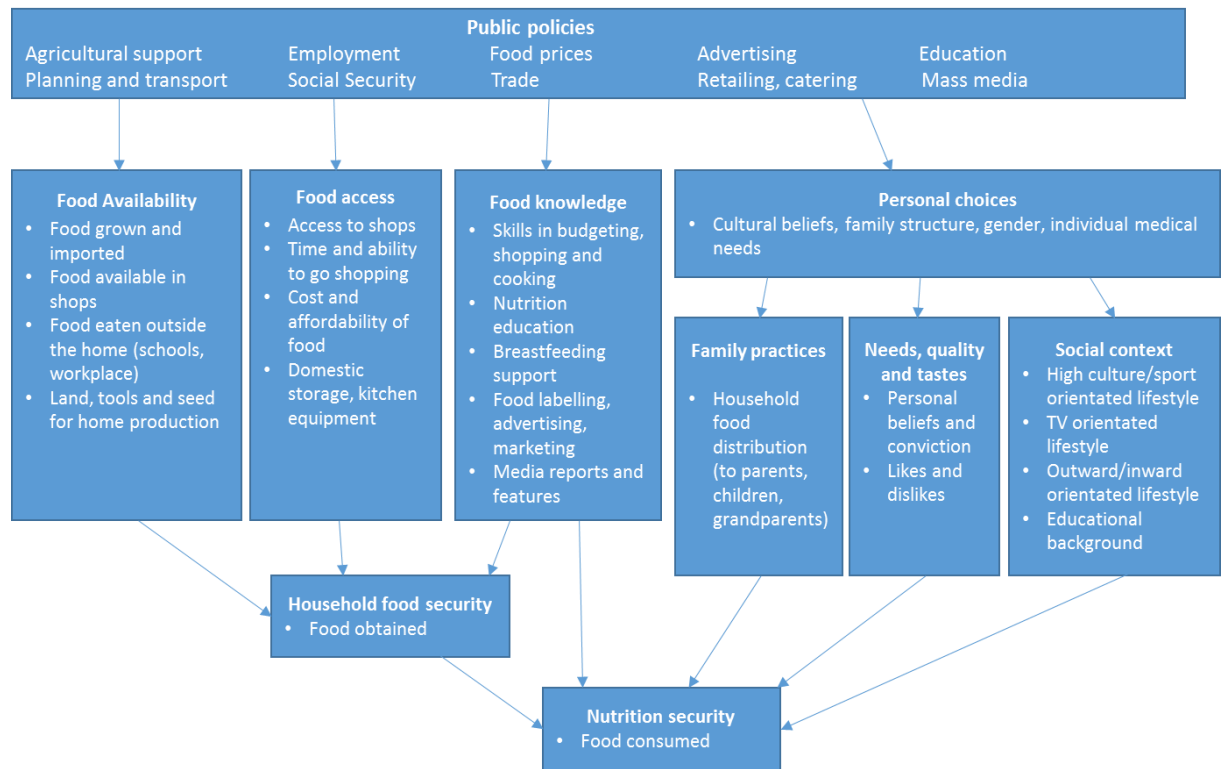
¹¹ "Fruit Juice" was not defined, and assessment of "fruit juice" was based on self-reports of parents.

- Findings from the peer-reviewed and grey literature show evidence that SES drives food choice, cooking, and physical activity. SES was also found to drive healthy or unhealthy dietary behaviours. For example, healthy dietary behaviours include a diet that is high in fibre and low in fat, salt or sugar
- Individuals with lower SES status are less likely to engage in healthy dietary behaviours and physical activity
- Food purchasing behaviours may vary across countries along with the availability of items in the food environment.
- Consumer perceptions, attitudes and taste preferences influence food purchasing. These individual level factors are influenced by perceived importance of taste, nutrition, cost, and convenience, advertising, and the spatial layout and marketing strategies of supermarkets.
- Being female was a main correlate of whether someone cooks, and is strongly associated with cooking skills, time spent cooking, and having the main responsibility for preparing food for the family.
- Higher SES, living with others and having more free time were found to be associated with cooking.
- Improved health was the main motivator for engagement in physical activity, with other factors such as appearance and pleasure also being important.
- Social and physical environments that are structured to promote physical activity (e.g., presence of sidewalks or recreational facilities) have been shown to enable community members to engage physical activity.
- Social and physical environments, such as supermarket promotions/pricing and advertising, can influence dietary behaviours.

3.2.2 Drivers of dietary behaviours (shopping, cooking and eating)

These findings are presented within a framework adapted from Robertson, Torado and Lobstein (2004) that was identified through the grey literature review. This framework identifies four main categories of influence on food choices: 1) food availability; 2) food access; 3) food knowledge; and 4) personal choice. Examples from each category are provided in Figure 1, which demonstrates the complex hierarchy of factors influencing the purchase, preparation and consumption of foods. The policy influences described in this framework are considered as part of another review in this series, A2.

Figure 1. Influences on food choices



Source: ICF, adapted from Robertson, Tirado, Lobstein et al, 2004

Peer-reviewed and grey literature findings related mainly to three of the four main categories of influence on food choices as presented above. These included: food availability, food access; food knowledge and personal choices. However, there was a small amount of evidence on food availability. Large scale surveys of shoppers across the EU indicate that gender, age, and socio-economic status are associated with food and nutrition knowledge, although the associations between these individual factors and food choice contexts are not identified. However, survey research regarding drivers of food behaviour identify that lower socio-economic groups are less likely to choose healthy foods (e.g., fruits and vegetables). In some instances, these choices are driven by perceptions that healthy foods are not affordable as compared to other available food in consumers' micro-level contexts.

Often, the evidence discussed influences on multiple or interlinked behaviours (such as shopping *and* consumption). Consequently, these findings have been grouped together but the specific behaviour is highlighted where possible for ease of understanding.

Food availability

Food purchasing behaviour may vary across countries along with the availability of items in the food environment. Pettinger et al. (2007) conducted a cross-sectional study examining food shopping patterns among a sample of food shoppers in Central England (n=826) and Southern France (n=766) using self-administered surveys. The authors found that respondents in England used supermarkets more often, while respondents in France purchased foods from small local shops more often (e.g., bakery, butcher, small markets). Respondents in both countries were also asked about the availability of fruits and vegetables as well as snack foods (e.g., crisps, fried snacks, confectionary, or cakes and biscuits). Shops in England were as likely to stock fruits and vegetables of comparable quality as shops in France. However, respondents living in

England reported a greater availability of energy-dense snack foods, such as fried snacks and confectionary items. The authors identified this widespread prevalence of energy dense foods in England as compared to France, along with England's more liberal, culturally embedded, snacking behaviours as a possible suggestion for the higher prevalence of obesity in England.

Food access

Lower SES is a key driver of food purchasing and consumption, because it decreases the means to purchase particular food items and is associated with the perception that healthy foods (e.g., fruits and vegetables) are too costly to purchase. In a survey of low-income French adults aged 30-60 (N=295), Bihan et al. (2010) analysed various determinants of low consumption of fruits and vegetables. Determinants identified by researchers included the absence of financial means for purchasing fruits and vegetables daily and the perception that fruits and vegetables were not affordable. Turrell and Kavanagh (2006) explored the socio-economic position and food purchasing behaviour among a sample of Australian adults (N=1,000) aged 28-62. Respondents living in low income households were less likely to purchase healthier foods (i.e., foods high in fibre or low in fat, salt or sugar¹²). The authors found that this association noticeably weakened when findings were adjusted for concerns about food costs¹³, but the relationship could still be considered strong. Concerns about food costs were independently associated with purchasing patterns. Aggarwal et al. (2016) analysed responses of adults (N=8957) from the U.S.-based National Health and Nutritional Examination Survey (NHANES 2007-2010). Cost was the third most important reason cited for dietary choices (40% of participants), with taste cited by 77%, nutrition cited by 60% and convenience by 30% of the sample. However, the lowest-income participants were three times more likely to identify cost as an important factor when purchasing food, and twice as likely to report convenience as being important.

In the grey literature, findings from pan-European and individual country-based surveys also found that cost is a key driver of dietary behaviour. Solbes and Byrne (2001) report on the European Community Household Panel which included surveys of 60,500 households annually from 1994 to 2001, representing 12 European countries. The survey identified that 10% of households could not afford to eat meat/chicken/fish at least once every two days. This percentage was much higher in Greece, where 48% of households could not afford to eat meat/chicken/fish at least once every two days. Solbes and Byrne also report on a 1996 pan-EU survey by the Institute for European Food that interviewed over 14,000 people, aged 15 and older, examining the attitudes to food, nutrition and health. They found that the importance attached to price when purchasing food ranged from 18% of respondents in Greece/Luxembourg to 62% in Finland. The contradiction between these two findings was not explored further by Solbes and Byrne, but may be attributed to differing survey methodologies and question wording.

Kambek et al (2013) conducted a secondary analysis of the 2005/2006 Health Behaviour in School-aged Children (HBSC) survey conducted in Estonia to model the socioeconomic determinants of dietary habits. They analysed the dietary habits of 4477 pupils, aged 11-15 years, in Estonian general education schools. They found that the socioeconomic status of an adolescent's family is likely to have a large impact on the types of food they themselves consumed. Adolescents in families with three or more children were less likely to eat fruit and vegetables compared to adolescents in families with only one child.

In the Baltic nations (Estonia n = 2018; Latvia n=2308; and Lithuania n=2153), Pomerleau, McKee and Robertson et al. (1999) found that cost was a key driver of

¹² Food purchasing was measured using a 16 item index reflecting dietary guideline recommendations

¹³ Food-cost concern was measured using a three-item measure, with statements relating to cost and healthiness of food

dietary behaviour. The study was based on cross-sectional surveys with nationally representative samples of adults in each country. In addition, the authors noted that increases in food prices in Lithuania resulted in lower SES groups consuming cheaper, less healthy food.

In the UK, Opinion Leader Research (2004) found that 84% of people from 'semi-skilled; unskilled manual occupations; unemployed; and lowest grade occupations' and 73% of people 'from higher and intermediate managerial; administrative; and professional occupations' felt that fruit and vegetables should be more affordable. This survey found that consumers felt the government should provide the money and resources needed for a healthier diet, even if this meant subsidising food chains, supermarkets and healthier food options.

However, individuals in lower SES brackets are more likely to purchase non-core dietary items (e.g., sugar-sweetened beverages) regardless of the shopping context. Vinkeles et al. (2009) conducted a study examining food purchasing behaviour among adults in Australia (N=204). In their study, 102 adults from high income areas and 102 adults from low-income areas were asked to submit food shopping receipts to researchers. The availability of snack foods were quantified by measuring the dedicated shelf space for non-core foods such as confectionary, sugar-sweetened beverages, sweet biscuits and cakes and crisps and popcorn. The amount of shelf space for these items did not differ between the stores located in low-income versus high income areas. However, the authors found that low-income shoppers purchased significantly more non-core items than high income shoppers.

People with low SES may lack adequate transportation, which in turn, creates barriers getting to stores. Robertson, Tirado and Lobstein et al. (2004) in their book on food and health in Europe draw together available data to demonstrate the links between health, nutrition, food and food supplies as outlined in the First Action Plan for Food and Nutrition Policy (WHO European Region, 2000–2005). They found that families on a low income were not able to engage in activities that others in the same neighbourhood were able to do. Cost was central to not being able to engage in activities such as inviting friends for meals, eating at restaurants or having access to a car in order to go shopping. The distance to shops and supermarkets and the transport needed to get there can be an issue for some people that find it difficult to travel to stores where healthier foods are more affordable. Kambek et al. 2013 in their analysis of 2005/6 HBSC data, also found that adolescents living in rural areas were less likely to eat fruit and vegetables compared to adolescents in urban areas, further suggesting that distance to stores can affect consumption patterns.

Food knowledge

There was limited, mixed evidence of the link between education or nutritional knowledge and purchasing behaviour. Turrell and Kavanagh's (2006) study of 1000 Australian adults, found a link between education and food purchasing behaviour. The authors identified that respondents with low levels of education were less likely to purchase healthier foods (i.e., foods high in fibre or low in fat, salt or sugar). The authors also examined respondent knowledge about nutrition and found an association with food purchasing behaviour (Turrell & Kavanagh, 2006).

Cross-sectional evidence found a link between nutritional knowledge and attitudes to healthy eating, but did not support a link to purchasing behaviour. In a survey of shoppers from the UK, Sweden France, Germany, Poland, and Hungary (n=5967), Grunert, Wills, Celemin, Lähteenmäki, Scholder, and Bonsmann (2012) found differences in level of nutrition knowledge¹⁴ were associated with socio-demographic characteristics,

¹⁴ Regarding dietary recommendations, sources of nutrients and calorie content of different foods and drinks.

consumers' attitudes towards healthy eating and use of different sources of food knowledge. Shopper's attitudes towards healthy eating were related to the level of nutrition knowledge but there were exceptions - the authors found that older people have less nutrition knowledge, but more interest in healthy eating than other age groups. Women and individuals in higher socio-economic levels had more nutrition knowledge. There was a weak association between shoppers' attitude to healthy eating and information use of nutrition knowledge. However, no additional tests were conducted to identify whether this food knowledge was associated with food purchasing patterns.

In the grey literature, individuals with higher levels of education may be more likely to eat a healthier diet.

A Nordic study (Nordic Council of Ministers 2014) identified a link between education and diet. This survey explored the frequency of food intake for specific food, physical activity levels, prevalence of overweight in the population, and social inequality. A total of 9153 adults and 2479 children completed indicator-based surveys in the Nordic countries. The study found that the higher an individual's level of education, the more likely they were to make healthier food choices (e.g., less consumption of sugar-sweetened beverages). Results indicate that both men and women with higher educational levels had healthier diets and eating habits, favouring oils to cook with (instead of solid fats), and consumed low fat spreads and lower levels of soft drinks.

Advertising and marketing can also play a role in promoting healthier behaviours or encouraging unhealthy behaviours.

Grey literature (Dibbs and Harris 1996, Wolfram 2000 and Tatlow-Golden et al 2016) highlighted the link between advertising and marketing and either consumption or purchasing behaviour. Wolfram's (2000) report on nutrition, based on interviews with 20000 German-speaking people found advertisement and marketing was a key influencer of consumption. They reemphasise the positive role that advertisement and television broadcasting should take in promoting and broadcasting healthier messages.

Dibb and Harris (1996) highlight the strong evidence base for the link between advertising/marketing and children's food consumption, where children are often influenced by products they see advertised. In their study of digital food marketing aimed at children, Tatlow-Golden et al. (2016) report that adolescents are more susceptible to advertising of foods high in saturated fats, sugars and salt. They draw on a content analysis carried out by The British Heart Foundation (2011)¹⁵ of food brand and product websites targeted at children, including snacks and breakfast cereals. From their examination of 100 websites, 80% of advertising included products that were not permitted to be advertised to children on television under UK broadcast regulations. The marketing campaigns were also interactive; they were linked to social media networks and contained cartoons, animations, characters, games and competitions, and downloadable content. Tatlow-Golden et al. suggest that despite adolescents' increasing cognitive ability, they are likely to be: impulsive due to neurological and hormonal changes during puberty; subject to peer influence because of the time spent with them; more likely to engage in risky behaviour; and, typically have independent spending money. As a result, adolescents are more likely than younger children to be affected by marketing and advertising, and are more likely to buy high fat, salt and sugar (HFSS) foods. Tatlow-Golden et al argue that more research into the impact of digital forms of marketing and advertising on consumer preferences and food choices is needed.

The environment within grocery stores shows evidence of influencing consumer behaviour, particularly promotions. In an unpublished thesis, Thompson (2012) reports findings from her qualitative study of 26 Sandwell (West Midlands, England)

¹⁵ The 21st century gingerbread house: how companies are marketing junk food to children online. London: British Heart Foundation; 2011.

residents. This study provides insight into the motivations for consumption of people living in a relatively deprived area. Thompson identified a range of important patterns in both shopping and preparing/eating food. Through food photo diaries, interviews and observations of food shopping trips ('go-along interviews') she found that participants:

- expressed a preference for a wide range of choice in relation to grocery shopping, regardless of their budget.
- were drawn in by novelty and price promotions.
- interacted with shopping aisles in particular ways depending on what they needed to purchase or where they expected price promotions to be located.

Personal characteristics and choices

We adapted the personal choice aspect of Robertson, Tirado, and Lobstein et al.'s (2004) framework to encompass aspects of people's lives that are related to their sociodemographic characteristics and how they spend their time. The following factors were identified as related to different dietary behaviours: personal taste; attitudes to health; perceived quality or freshness; gender; household size;

Personal taste, attitudes to health and perceived food quality are drivers of dietary behaviour. In the same analysis of 8957 survey participants by Aggarwal et al. (2016) discussed previously, taste was the main reason cited for dietary choices. Seventy-seven percent of participants in the National Health and Nutritional Examination Survey (NHANES 2007-2010) identified taste as very important, followed by nutrition (60%). In an analysis of determinants of fruit and vegetable consumption of 295 low-income French adults, Bihan et al. (2010) also found that attitudes regarding whether fruits and vegetables improve health, whether one's diet is considered healthy, and whether eating fruits and vegetables is a pleasure all had a positive influence on consumption.

In the grey literature, quality (freshness and food safety) and price were identified as the top two determining factors when buying food (CENSIS, 2010; Eurostat, 2009; Solbes and Byrne, 2001). For example, the pan-European survey cited above (over 14000 people interviewed) found that quality of food was the key driver of dietary behaviour (Solbes and Byrne, 2001). The survey found that less than 5% of respondents made choices based on dietary requirements, cultural factors or the packaging of food. Country specific data from Germany based on a survey of 20000 people showed that "taste" and "freshness" were significant drivers for consumption in the German population (Nationale Verzehrs StudieI, 2008).

Being female was a main driver of cooking and strongly associated with cooking skills, time spent cooking, and more often preparing food for the family. In a review of the UK National Diet and Nutrition Survey (2008-2009), researchers examined socio-demographic correlates of cooking skills among adult (n=509) respondents. Although there is no consensus on what is the most appropriate measure of cooking skills, Adams et al. (2015) assessed skills via self-report. These self-report measures included assessment of eight cooking techniques, confidence in cooking ten foods, and the ability to prepare four types of dishes (convenience foods, complete meal from ready-made ingredients, a main meal from basic ingredients, and cake or biscuits from basic ingredients). There were few socio-demographic differences reported in cooking skills, and 90% of respondents reported confidence with cooking and being able to prepare a meal from basic ingredients. However, women reported confidence with a greater number of cooking techniques when compared with men, as well as reporting more time spent cooking (Adams et al., 2015).

Another UK study also aimed to measure socio-demographic correlates of time spent cooking by adults in the 2005 UK Time-Use survey (n=4214). Socio-demographic variables of interest were: age, employment, social class, education, and number of

adults and children in the household. Gender was a stronger determinant of time spent cooking, with women spending significantly more time cooking within a 24 hour period than men (Adams & White, 2015).

Small differences in snacking were found to exist by gender within the Netherlands. More research needs to be conducted to assess whether gender is a driver of more general eating behaviour. Adriaanse et al. (2015) conducted an internet survey panel based on a probability sample of households in the Netherlands. Respondents kept a seven-day food diary (n=1292) and gender differences in snacking behaviours were analysed. The authors found that women consumed more snacks than men (both healthy and not healthy), finding that while small differences in psychological factors related to this kind of eating exist, they are not large enough to support the need for targeting healthy eating interventions based on sex. There was no difference between men and women with regard to intentions to eat more healthily and external eating (the tendency to eat in response to external cues), the two factors that best predicted snack intake (Adriaanse et al., 2015).

Three additional references from the grey literature indicate that there are gender differences with regard to dietary behaviour. While Pomerleau, McKee and Robertson, (1999) found taste to be more important to men (44%) than women (33%) in the Baltic Republics, when deciding what to buy and eat, the Nordic Council of Ministers (2014) and Mann-Luoma (2003) both found that females were more likely to place a higher emphasis on maintaining a healthy diet. The Nordic study led by the University of Iceland found that females had healthier habits than men, including a higher consumption levels of fruit and vegetables, a lower fat intake, and lower levels of soft drink consumption. These gender differences are supported by Mann-Luoma's (2003) study that found gender influenced the shopping and eating patterns of adolescents, with boys increasingly likely to choose unhealthy options. This was found to be closely related to the different types of lifestyles that adolescents have, (e.g. more television orientated). There was little evidence in these studies as to why these gender differences occurred.

Living with others is associated with time spent cooking and different eating patterns Adams & White (2015) in their examination of socio-demographic correlates of cooking skills among adults (n=4214) in the UK found that living with other adults or children was positively associated with time spent cooking. The cross-sectional analysis by Berge et al. (2016) of the U.S.-based EAT2010 and Project F-EAT also found that parent and adolescent report of 'usually preparing food for the family' was related to household size (less than or equal to three children). In Thompson's (2012) thesis, study participants were influenced by family dynamics, a negotiation of the food preferences of different family members and facilitating meals for fussy eaters at home.

Occupation and available free time affect ability to prepare food In the cross-sectional analysis of adolescent (n=2108) and parent (n=2,975) survey data, Berge et al. (2016) found that parents who reported they stay at home or were employed part time were more likely to report that they prepared food for the family. Using data from two longitudinal studies, the Three-City Study in France and the Quebec Longitudinal Study on Nutrition and Successful aging (n=9294), Allès et al. (2016) studied socio-demographic characteristics correlating to certain dietary patterns among older adults. They examined the relationship between characteristics and a balanced, healthy diet and a "Western" diet pattern characterized by high intake of animal protein from dairy and cured meats and lower intake of vegetables, cereals, legumes, and other foods. Higher education and having a non-physical occupation¹⁶ across one's lifetime was associated with a healthy dietary pattern in both studies.

¹⁶ Terminology used in study

Type of lifestyle and other social contextual factors influence different dietary behaviours. Grey literature reported links between the type of lifestyle that people have and their food choices (Mann-Luoma, 2003). This study of 400 students from three different secondary schools in East Germany found that lifestyles that are centred at home (inward oriented lifestyles) favour sedentary activities such as watching television or playing/working on computers. These then encourage unhealthy habits such as snacking and eating confectionary items that are high in saturated fats and sugars. Mathieson and Koller (2006) also report findings of television viewing behaviour and associations with food habits in different countries: those who watch more television are more likely to consume sweets and soft drinks and less likely to eat healthy meals consisting of fruit and vegetables. Finally, Boyce, Robertson and Dixon (2008) suggest that various social and environmental contextual factors contribute to individual choices related to dietary behaviour, including: the availability of passive entertainment (for example the amount of time watching television and engaging in computer based activities); the perception of obesity and physical activity norms across socio-cultural groups; the extent to which children control their own diet; and the degree to which food intake is based on habit and routine.

A3.2.2.1 Drivers of physical activity behaviours

Parental and social support affect physical activity. In a systematic review of 35 articles, Park and Kim (2008) address factors associated with adolescents' physical activity. The authors found multiple demographic variables that correlate with physical activity behaviour. Researchers found that social and parental support, specifically parental modelling of healthy physical activity behaviour, are important factors in adolescents' self-efficacy perceptions as well as higher participation in physical activity.

In their national cross-sectional mail out panel survey of U.S. adults (n=5914) over a 3-month period, Blanchard et al. (2005) measured the effect of weight, social support, self-efficacy, and access to workout facilities on physical activity. The authors found that the level of social support received by each weight group (healthy weight, overweight, obese) was similar and had a significant association with physical activity for all three weight groups. Results also showed that for normal weight and overweight individuals, as the level of social support increased, the number of days of physical activity engagement was greater if they reported higher levels of self-efficacy. Self-efficacy was significantly lower in obese participants compared to the normal weight and overweight participant groups.

Findings from the grey literature indicate those of low SES may experience more barriers to physical activity. Motivators for engaging in physical activity may differ by high and low SES groups. Cavill, Kahlmeier and Racioppi (2006) in their physical activity report for the WHO found that low-income residents tend to have less free-time to participate in physical activity, poor access to places to engage in physical activity such as recreational facilities or streets with sidewalks. The findings also showed that families from lower socio-economic backgrounds were more likely to live in urban areas that have high -speed traffic and poor road safety; thus, these families were less likely to walk/cycle to school or their place of work.

SES was also identified as an influencing factor for physical activity in a Eurobarometer survey¹⁷ (European Commission 2010; 2013). The 2010 survey found that those from lower SES groups were less likely to exercise for health reasons (51% compared to 64% of those from higher SES groups) and for the enjoyment of exercise (22% compared to

¹⁷ The Eurobarometer survey carried out by TNS Opinion & Social Network (2010; 2013)¹⁷ on sport and physical activity was based on interviews with nearly 27,000 citizens in 27 Member States (European Commission 2010; 2013).

34% of those from higher SES groups). The 2013 Eurobarometer survey does not have comparable data, however it highlights that people who have more disposable income are more likely than those with less disposable income to believe there are sufficient opportunities for physical activity in their area (81% against 63%).

The Eurobarometer survey (2010) also showed correlations between educational level and motivations for engaging in physical activity. It found that individuals 20 years of age or higher with higher levels of education perceived participating in physical activity with a better quality of life. Respondents with higher levels of education reported that they were more likely to be driven by the fun and enjoyment of physical activity. Thirty-six percent of those that left education at the age of 20 or over reported taking part in physical activity because it was enjoyable compared to 20% of those that left education at the age of 15 or younger. Participation figures showed that 64% of people that left school under the age of 15 were not physically active, compared to the 39% of people that left education between 16-19 years old and the 24% that were in education after the age of 20 who were physically inactive (across the 27 member states included in the survey). In 2013, the proportion of people who engaged with sport and physical activity in order to relax varied by educational differences: 27% of people who left education by the age of 15 engaged in sport or physical activity (as compared to 44% who left education at age 20 or older). The Nordic study cited previously supported this finding, showing that people with higher levels of education were more active (Nordic Council of Ministers, 2014).

Factors motivating people to be physically active differ by gender. In the 2010 Eurobarometer survey, it was also found that females were marginally more health-conscious than men, finding that 63% of females and 58% of men exercised for health reasons. Closely associated with this was the finding that more women (25%) than men (22%) exercised to improve their physical appearance. In contrast, men (35%) were more likely to be motivated by the fun attached to physical activity than women (27%) and by spending time with their friends (25% and 19% respectively). This finding varies little from the 2013 survey. Overall, men were slightly more likely to be motivated by the fun of exercise (33% compared with 27% of women), being with friends (23% compared with 17% of women) and by the competition (8% compared with 3%) than women. On the other hand, women were more likely to be motivated by weight control (26% compared with 23% of men) and countering the effects of aging (17% compared with 14% of men). In contrast, a Nordic study found that there was no significant difference between the activity levels of men and women (Nordic Council of Ministers, 2014), suggesting that there are differences between Member States.

Findings from the grey literature suggest that individual desires, aspirations and experiences drive physical activity and motivation to undertake it. The Eurobarometer survey in both 2010 and 2013 found that a desire to improve health was the main motivator for physical activity, with other factors such as appearance and pleasure also being important (European Commission, 2010; 2013). The 2013 survey found that EU citizens took part in sport or some form of physical activity for health reasons (61% in the 2010 survey); followed by exercising to improve fitness (41% in 2010 and 40% in 2013); to relax (39% in 2010 and 36% in 2013); and to have fun (31% in 2010 and 30% in 2013). The drivers for physical activity did not change substantially from the 2010 to the 2013 survey. Whilst 24% of EU citizens took part in physical activity to improve their physical image, the 2010 study also identified other drivers for physical activity including spending time with friends; relaxation; weight control; improving self-esteem; and counteracting the effects of aging.

Both Eurobarometer surveys identified barriers to engaging in physical activity: time (45% in 2010 and 42% in 2013); and illness/disability (13% in 2010 and 2013) were the most commonly cited barriers. Other barriers included lack of interest in competitive

activities (7%); the cost of activities was regarded as too high (5% in 2010 and 10% in 2013); lack of suitable facilities (3%); and lack of friends to be physically active with (3%). Although the 2010 survey showed that 54% of EU citizens were interested in engaging in physical activity, 42% said they would rather do other things in their time. Thus, just under half of EU citizens in the 2010 study lacked motivation to engage in physical activity. This is especially true for those in the middle age bands. For example, in 2013, lack of time is mentioned by 58% of 25-39 year olds and 53% of 40-54 year olds.

Feelings of tiredness and wanting to relax in free time were also noted in a 2006 WHO report (Cavill, Kahlmeier and Racioppi, 2006). This report also found that psychological factors such as self-confidence and not regarding oneself as 'sporty' played a role in how physically active one is.

Physical aspects of, and perceptions of, the living environment influence physical activity

Duncan et al. (2005) conducted a meta-analysis of 16 studies to assess the impact of the environment on physical activity. The studies were conducted in the US, Australia and England and considered one or more of the following measures of physical activity: 1) walking, 2) walking for transportation, 3) sufficient leisure-time physical activity and 4) sufficient physical activity. Findings from the meta-analysis showed that physical activity was associated with the (perceived) presence of sidewalks, shops nearby, physical activity facilities and reports that traffic was not a problem.

Blanchard, et al. (2005) found that obese individuals (N=5914) reported having less access to fitness facilities in their neighbourhoods. However, as access increased, the number of days obese participants were physically active was higher when they reported having a higher self-efficacy or belief they could succeed (Blanchard et al., 2005).

De Bourdeaudhuij et al. (2005) conducted a cross-sectional study in one city in Portugal (n=526) and in Belgium (n=279), to investigate the environmental and psychosocial variables in explaining physical activity levels of urban adults. Though there were differences in the Portuguese or Belgian cities, adults in both sites reported environmental factors, such as sidewalk availability, higher connectivity of streets, and higher residential density, as facilitators of walking or cycling for transportation, exercise, and recreation. Leisure-time physical activity was more related to the presence of recreational resources, either in the home or the community. Additionally, social support and social norms increased the pleasure of physical activity for adults during their leisure-time. As above, De Bourdeaudhuij et al. (2005) also found that leisure time/recreational physical activity was associated with self-efficacy.

In the grey literature, Edwards and Tsouros' (2006) review of evidence on physical activity and active living in urban environments found that motivations for participating in physical activity are influenced by the built, natural and social environments. Their report illustrates how concerns about safety and security act as barriers to being physically active. They argue that physical environment in terms of the ways in which communities, living and working environments are built is critical in influencing whether people are more likely to use public transport or walk/cycle to their destination. Boyce, Robertson and Dixon (2008) also argue that an increase in motorised transport has resulted in fewer people walking or cycling, and a lack of green space may act as a deterrent to people participating in running, walking or other sports activities.

3.3 Research Question 3: How can these behaviours/choices be nudged so as to become healthier?

3.3.1 Summary

- Food labels help consumers identify healthy items; however, they may not motivate consumers to make healthy choices.
- Product placement influences food choices; the strength of the effect may depend on the manipulation of the product and the proximity to the consumer.
- Increasing the proportion of healthy options available may result in individuals selecting more of them.
- Incentivising healthier items through lower costs may be a promising strategy for encouraging healthier food/beverages choices.
- Nudging people to be more physically active may include physical (stair prompts, increasing attractiveness of the physical activity environment), economic (decreasing the price associated with structured physical activities, increasing the cost of parking a car), or political (rewarding physical activity, dis-incentivizing physical inactivity) approaches.
- Limiting screen time may be effective to nudge children to become more active.
- Improved access to facilities or equipment may improve physical activity levels.
- Physical activity could be encouraged through promoting the use of stairways, both in the workplace and in other public buildings.
- More research is needed to determine what may best nudge individuals to be more physically active.

3.3.2 Nudging Dietary Behaviour

In response to the growing obesity epidemic, many policymakers, public health professionals and countries are searching for means to effectively and efficiently improve dietary behaviours and increase physical activity. Changes to the micro-environment that present ways in which people can be “nudged” to make healthier choices is a strategy that has been gaining attention in the public health community. Current findings related to interventions that nudge people to make the healthier choice are presented here.

Nudge strategies resulted in a 15.8% improvement in dietary behaviours and food choice. Arno and Thomas (2016) conducted a systematic review and meta-analysis to explore the effectiveness of “nudging” strategies with regard to dietary behaviour. Their review included 42 international peer-reviewed studies from between 2004 and 2014¹⁸ including randomised control trials (n=31), cross-sectional studies with pre-post comparison (n=9) and one cohort study. They were conducted in a variety of settings (laboratory, restaurant, market, canteen/cafeteria, home, online and movie theatre). Nudge strategies considered included:

- Changing placement of food/increasing availability of healthy food (n=7)
- Nutrition labelling (n=13)
- Changing the size of serving containers or size of eating utensils (n=6)
- Adjusting the portion size (n=16)

The authors found that as a result of these nudging strategies described above, there was, on average, a 15.3% increase in healthier consumption decisions, as measured by frequency of healthier choices or overall calorie intake. The authors did not specify which strategy had the biggest impact. They concluded that nudge strategies may hold promise

¹⁸ US (n=31), Belgium (n=2), Japan (n=1), United Kingdom (n=4), the Netherlands (n=3) and Australia (n=1).

in addressing dietary behaviour and the more distal outcome of obesity, but more research in diverse settings is needed.

The grey literature indicates that supermarkets are settings in which a large variety of nudges or choice architecture constructs may be implemented. In the grey literature Palmer (2012), in his thesis on nudging shoppers towards healthier food choices, constructed fifteen nudges, which he termed choice architecture constructs, based on a rapid literature review. These are presented in Figure 2.

Figure 2. Supermarket choice architecture constructs

Choice architecture construct	Description
Healthier products at checkout	Displaying healthier products at supermarket checkouts e.g. appealing fruits
'Goes well with' signage	Signage that informs consumers about products that go well together e.g. 'red cabbage goes well with honey, apples, dried apricot and lime juice'.
Eye-level	Displaying healthy products at eye level and unhealthy products at the bottom of shelves.
Complementary unhealthy & healthy products	Placing unhealthy products adjacent to healthy products e.g. placing vegetables next to frozen hamburgers.
Promotions	Offering multi-buy promotions on healthier products such as fish and vegetables.
Interactive consumer voting	Display an interactive voting system where consumer can see how many customers 'like' specific products.
Recipes	Making recipes available at the entrance of supermarkets to help customers at the beginning of their shopping journey.
Online shopping	Offer an online shopping experience that is tailored to the health and nutrition needs of the customer e.g. in relation to their age, body mass index and health conditions.
Product size	Offer consumers a break in consumption through introducing products of smaller size or combi-packets.
End-of-aisle	Place healthy products at the end of aisles.
Hard to reach	Place healthier products in positions that are easier to reach and unhealthy ones further away.
Shopping basket	Place visual cues in shopping baskets that offer consumers information on nutritional guidelines and recommended daily intake.
'Emotionally intelligent signage'	Offering signage displays informing consumers that more people are eating more fruit/vegetables.
'Back-of-pack recipes'	Food manufacturers to include recipes at the back of their products to encourage consumers to buy healthier meals.
Communication between shoppers and employees	Wearing 'how may I help you?' badges so that consumers are encouraged to ask employees questions about healthier food selection within different food categories.

Source: ICF

The thesis does not discuss the impact of these different constructs, but illustrates the many potential applications of the choice architecture concept that would benefit from further exploration.

Food labels help consumers identify healthy items, but the labels may not motivate consumers to make healthy choices. Three randomised controlled studies included in this review examined food labelling as an influence on food choice. In a study conducted with a sample of 1,000 adult consumers in Poland and Germany (Aschemann-Witzel et al., 2013), researchers manipulated the food labels' colour-coding, text, and percentage of guideline daily amount (GDA) to determine if front-of-pack nutrition label formats influence the healthiness of food choices among adult consumers. When consumers were asked to choose foods based on nutritional contents, two label elements that increased the healthiness of choices included colour coding and texts. However, they did not influence consumers' motivation to choose healthy foods. When consumers were left to select the food items they wanted most, and not prompted to consider the most

nutritious option, food labelling did not have an influence in consumers making a healthy choice. The authors found that colour coding did, however, increase consumers' perceived capability of making healthy choices.

Another randomised control trial (Borgmeier & Westenhofer, 2009) also examined different food label formats to understand what helps adult consumers (n=426 adults aged 21-54) in Hamburg, Germany, to differentiate between more or less healthy foods. These researchers tested five different food label formats which included: a simple "healthy choice" tick, a multiple traffic light label, a monochrome GDA label, a coloured GDA label and a "no label" condition. Traffic light labels generated the highest percentage of correct choices. However, when consumers were asked to make choices, the information on the food labels did not influence food choice and did not differ significantly between the different label choices.

Babio et al. (2014) used a randomised cross-over study design to compare adolescents' (N=81 aged 16-18) decision between two models of front-of-pack Guideline Daily Amounts (GDA) labels, multiple-traffic-light or monochrome nutritional labels. The authors concluded that some types of nutritional label on front of packages are important and beneficial to consumers. Findings suggest that the multi-colour labelling scheme assisted adolescents to differentiate between less healthy and healthier foods. Nutritional labels using traffic light symbols were easily understandable to adolescents, and may be a promising strategy to help this age choose healthier food options.

The grey literature also discussed the role of nutrition labelling in nudging dietary behaviour. The 2014 WHO snapshot of successful nutrition policies across Europe highlights the example in Finland where salt reduction programmes started in the 1970's. Compulsory salt labelling was introduced in 1993 and products containing high levels of salt were required to have additional 'warning labels'. This was also accompanied by 'better choice' labels that showed products that had low levels of salt, therefore nudging consumers by presenting them with an alternative. Data cited in this source shows that salt intake decreased from 12g per day in 1970 and 6.5g for women by 2002, though no information on methodology or levels among men is provided (WHO 2014).

The position of labels on food items was also found to be an important factor in nudging behaviour by Engelhard and Garson (2009). They found that people are more likely to use the labels at the front of a product than those at the back, though there is little evidence as to whether these behaviours are sustained in the long term. They note that these front of pack labels are often in colour whilst much of the tabulated back of pack labelling is black and white. They note that colourful labelling such as the "traffic light" labelling discussed above has been found to be more effective than the black and white non-graphic numerical box labelling used in the USA. Data from the EU-funded project FLABEL (Food Labelling to Advance Better Education for Life) which explored the impact of food labelling among consumers, also found that consumers were more likely to pay attention to front-of-packaging labelling and that this was enhanced when also accompanied by a health logo to easily indicate healthier choices (FLABEL 2012).

Product placement influences food choices; the strength of the influence on food choices may be dependent on the manipulation of food product order and variations in the distance of food placement relative to consumers within microenvironments (e.g., groceries). A systematic review of 18 international studies investigated how food placement influenced consumers' food choice (Bucher et al., 2016).¹⁹ The effect of positional changes (e.g., proximity and distance) of food items in

¹⁹ The review included 15 articles (which included 18 studies) from the US and Europe (including four from the Netherlands). The majority (n=14) of studies' and articles' quality was rated as neutral by the authors. Between-subject experiments were the most common study design, with only one study using a longitudinal design as a means to measure subjects following participation in an intervention. Only a few studies measured food intake;

microenvironments (e.g., grocery stores) was examined in nine of the studies included. The other half examined food order or accessibility. Of the 18 studies reviewed, 16 demonstrated that positional changes had a positive influence on food choice, i.e., the consumer was “nudged” to select healthier foods. One reviewed study indicated that movement of non-healthy foods (e.g., potato chips) from proximity of consumer resulted in compensatory choices, i.e., the consumer chose an item in the same food category. The review also examined a study that assessed differences in food choices by participant weight and found that positional nudges (e.g., placement of high-energy food items) were effective regardless of consumers’ weight status (i.e., healthy or obese). Study subjects’ socio-economic status had no influence on the effectiveness of food positional interventions.

Foster et al. (2014) also examined the impact of product placement of healthier items on their purchases but in low-income, high-minority supermarkets in two cities in the U.S. Eight stores were included in the study, with four as the intervention and four in the control. The intervention stores changed the placement of lower-calorie products that were the same price as their less healthy counterparts to be more eye-catching with improved signage to promote the healthy choice in a stealth manner. Sales data were used to assess outcomes. After six months, it was found that simple placement and product availability strategies influenced the purchases of healthier items. Intervention stores demonstrated a modest increase in sales of 1% (low-fat) milk as compared to control stores. Interventions demonstrated to be effective were those that increased the facing of targeted (i.e., healthy) products. Interventions aimed at milk sales included reducing number of whole-milk (i.e., full-fat milk) facings by 30% and re-appropriate facings equally between whole, 1%, and 2% milk. Intervention stores also showed increases in purchases of healthier frozen meals than in control stores. Placement interventions for frozen meals included doubling targeted products’ (i.e., healthier meals) number of facings from one to two facings. The placement of products can be a determining factor in healthier choices, along with the economic incentive of the similarly priced healthier options.

Tailoring point of purchase messaging can be an effective nudging strategy Allan Johnston, & Campbell (2015) studied the effect of an environmental-level, point-of-purchase intervention designed to reduce the calorie content of customer purchases by reducing customers’ needs to utilize executive functioning cognition during purchases. The authors examine the intervention's impact in a sample of 128 adult customers. The intervention was targeted at consumption of "speciality" blended coffees and other drinks (e.g. energy dense latte or hot chocolate with cream and marshmallows) and energy dense snacks, and was conducted at a public coffee shop at a large UK academic hospital. The researchers displayed signs designating which snacks and which drinks had fewer calories during the intervention weeks. They compared the purchases during the intervention weeks to purchases during control weeks, during which no such signs were displayed. The purchases of high calorie snacks were significantly lower during intervention than control weeks. While the purchases of high calorie drinks were lower in intervention than control weeks, this difference was not statistically significant (Allan et al., 2015). The authors concluded that both educational materials and product placement were effective approaches for nudging customers to make healthier choices.

In a systematic review of nudging interventions in cafeterias/self-service settings, Skov et al. (2013) also found point-of-purchasing signage to be associated with healthier food choices. The review included 12 studies published between 1984 and 2012 with five

the majority assessed food selection or choice probability using tests of association (e.g., Chi-Square tests) The effect of positional changes (e.g., proximity and distance) of food items in microenvironments (e.g., grocery stores) was examined in nine of the studies included. The other half examined food order or accessibility.

focused on nutrition labelling. A brief summary of these studies is presented in Table 2 below.

Table 2. *Point of Sale Promotion and Dietary Behaviour: Summary of literature on nutrition included in the systematic review conducted by Skov et al.*²⁰

Author/Year	Setting	Design	Intervention	Result
Buscher et al., 2001	Cafeteria	Pre/Post-test experiment	Posters were displayed promoting: 2. Vegetable baskets 3. Pretzels 4. Yoghurt 5. Fruit baskets	1. No effect on vegetable basket sales 2. Increase in pretzel sales 3. Increase in yoghurt sales 4. No effect on fruit basket sales
Dubbert et al., 1984	Cafeteria	Non-randomised intervention	Low-calorie sign placed near low-calorie products at point of purchase	1. Increase in vegetable and salad purchase 2. No effect on entrée purchase
Freedman 2011	All-you-can-eat dining hall	Pre/Post-test experiment	Signs placed near French fries and salad dressing giving calorie content and example of small versus large portion size	1. Increase in the number of people selecting smaller portion of fries 2. No change in the number of people purchasing fries 3. No change in salad dressing choice or volume
Levin et al., 1996	Cafeteria	nRCT	Poster at entrance to cafeteria and heart symbol next to healthy entrees	1. Increase in the percentage of total sales from low-fat entrees
Vyth et al., 2001	Cafeteria	Cluster RCT	'Choices' logo assigned to healthy soups and sandwiches	1. Increase in fruit sales 2. No effect on soup or sandwich purchase

RCT= randomised control trial; nRCT=nonrandomised control trial

One source from the grey literature argues that use of point-of-sale prompts and labelling to change dietary behaviour is better suited for institutional settings than retail settings, but data are not provided to support the conclusion. Within the grey literature there were references to policy nudges that were

²⁰ Adapted from Skov et al. (2013), *Choice architecture in self-service eating settings* (pages 193-195). nRCT or non-randomised controlled trial is the terminology used by the author.

aimed at institutional settings, such as the workplace and schools. Bailey and Harper (2015) in their literature review on interventions for healthy and sustainable diets state that education and information campaigns including guidelines, labelling and certification have limited impact on rational consumer behaviour. They argue that consumers do not always make rational choices but often make contradictory choices. For example, a consumer who is trying to lose weight may buy a chocolate bar in the supermarket whilst queuing at the check-out where food is placed for impulse purchase. In this example, the retailer has designed the shopping environment to increase the likelihood of selling specific food items that consumers had no intention of buying before they entered the supermarket. They further argue that despite these interventions (education and information campaigns, guidelines, labelling and certification) being effective in commercial applications, they have limited sustained success in encouraging healthy behaviours, though there is insufficient discussion of the evidence they draw on. They state that in contrast, these nudges work well within institutional settings because this allows the government (or the administrative authority) to directly design the “choice architecture”.

Findings from a systematic review indicate that the impact of manipulating serving plates/bowls and/or utensils is mixed. In a systematic review conducted by Skov et al. (2013), the authors included four studies that examined the dietary behaviour and calories consumed as a result of interventions that changed the size of serving plates or eating utensils. Two of the four studies included in the review did not find evidence that these interventions had an effect on selection of dietary behaviour, measured as the amount consumed (Mishra et al., 2012 and Rolls et al, 2007 cited in Skov et al. 2013), . A high-level summary of these four studies is provided in Table 3 below.

Table 3. *Adjusting sizes of plates, bowls and eating utensils and impact on dietary behaviour: Summary of literature included in the systematic review conducted by Skov et al.*²¹

Author/ Year	Setting	Design	Intervention	Result
Mishra et al., 2012	Restaurant	Experiment	<ol style="list-style-type: none"> 1. Different sized forks tested in a restaurant 2. Small or big forks given to subjects with the same type and amount of food (food lab) 	<ol style="list-style-type: none"> 1. Big fork associated with less consumption in restaurant 2. Small forks associated with less consumption in lab <p>Therefore, no effect for fork size.</p>
Rolls et al., 2007	Food lab	Within-subject crossover experiment	<ol style="list-style-type: none"> 1. Subjects served a main course on 3 different occasions with a different size plate each time 2. Subjects served 700g 	<ol style="list-style-type: none"> 1. No effect on total consumption 2. No effect on total consumption 3. No effect on total consumption

²¹ Adapted from Skov et al. (2013), *Choice architecture in self-service eating settings* (pages 193-195).

Author/Year	Setting	Design	Intervention	Result
			at two different occasions on different size plates 3. Subjects served themselves at a buffet at 3 different time points – different size plates used each time	
Wansink et al., 2005	Food lab	Experiment	1. Subjects given tall slender bottle and short wide bottle both holding 32 oz.	1. Shorter, wide bottles associated with greater water consumption
Wansink et al., 2006	Food lab	2 x 2 experiment - 2 bowl sizes v 2 spoon sizes	1. Subjects given a small or large bowl to serve themselves 2. Subjects given a small or large spoon to serve themselves	1. Large bowls associated with larger self-serving 2. Weak evidence that bigger spoons associated with bigger self-serving

Arno and Thomas' (2016) systematic review and meta-analysis similarly identified studies that examined the relationship between serving bowls/plates and food consumption. These RCTs, conducted in laboratory settings found that smaller serving plates/bowls and serving utensils resulted in decreased food consumption

Findings from a systematic review exploring the impact of nudging intervention on vegetable consumption in a school setting were inconclusive. In a systematic review conducted by Nornberg et al. (2015), 12 studies were examined to explore the state of the evidence on using nudging interventions to improve vegetable intake. The studies were conducted in the US, Canada and Denmark and focused on the following intervention types: 1) offering free vegetables (n=4); 2) increasing the variety or number of vegetables (n=4); 3) pre-portioning vegetables (versus whole servings) (n=1); 4) introducing a salad bar (n=1); 5) providing point of purchase information (n=1); and 6) plate size. Overall, the impact of the nudging interventions on dietary behaviour was inconclusive. However, increases in vegetable consumption were noted among the studies where the intervention focused on increasing the amount and/or variety of vegetables available. The authors concluded that the rigor of the designs across studies was moderate to weak, and the geographical variation likely introduced additional contextual factors that may influence behaviour and explain the mixed findings.

Small-scale studies conducted with population sub-groups suggest that increasing the proportion of healthy options or reducing portion sizes available may affect healthier food selection. In their study, Bucher et al. (2011) examined the impact of providing more vegetable options on food choices. Ninety-eight students from the University of Zurich participated in the study. Participants were divided into three groups and provided with a replica buffet option. The first group was given carrots, pasta, and chicken, the second group was given beans, pasta, and chicken, and the third group were given carrots, beans, pasta, and chicken. Upon serving themselves from the replica buffet, their choices were measured and the results showed that students provided with the two-vegetable option were more likely to fill their plate with a higher proportion of vegetables. The authors conclude that by offering more healthy options within the food environment (e.g., availability of variety of vegetables), people will consume a higher proportion of vegetables. Burns and Rothman (2015) likewise found that a variety of healthy options - such as differing choices for fruits presented throughout the day - may nudge people to choose the fruit option that differed from the one they had earlier in the day. Skov et al.'s (2013) systematic review highlighted the impact of adjusting portion sizes. They reviewed a study conducted by Freedman and Brochado (2010) which reduced the serving of fried chipped potatoes in a paper bag from 88g to 44g over time. The study took place in an all-you-can eat dining hall and found that decreasing the portion size was associated with: 1) people taking more than one bag; 2) a decrease in the total grams of chipped potatoes consumed; and 3) decreased plate waste. These studies, although promising, are limited by small sample sizes of particular sub-groups (i.e., students) who are likely to be unrepresentative of the whole population.

Incentivising healthier items through lower costs or using interventions that focus on payment methods may be promising strategies for encouraging healthier food/beverages choices. In their systematic review of 12 articles assessing the impact of nutrition interventions aimed at improving nutritional content of selections in vending machines, Grech and Allman-Farinelli (2015) found that reduced prices for healthier items contributed to an increase in their sales. The interventions which focused on the increased availability and competitive pricing of healthier items in vending machines found that this strategy was associated with increased sales of healthier foods/beverages.

One of the studies included in the systematic review by Skov et al. (2013), described an experiment examining the impact of payment method on dietary behaviour among college students. The study which was conducted by Just et al. (2008) and examined the impact of three conditions: 1) unrestricted payment plus \$10 cash; and 2) restricted (to healthy food prepaid debit card and \$10 cash or \$20 cash only. Findings from the study indicated that use of a prepaid debit card restricted to healthy foods resulted in more healthy foods selected when compared to students who were assigned cash or general debit cards as the method of payment.

3.3.3 Nudging to Make Physical Activity Behaviours Healthier

Our review found fewer articles on this topic when compared to articles describing nudging to improve dietary intake. Kremers et al (2012) provide a useful summary - approaches nudging people to be more physically active may include physical (stair prompts, increasing attractiveness of the physical activity environment), economic (decreasing the price associated with structured physical activities, increasing the cost of parking a car), or political (rewarding physical activity, dis-incentivizing physical inactivity). This review found limited evidence that specifically examined how altering the choice architecture relating to physical activity is effective. What we did find has been shown to increase physical activity included:

- using stair prompts;
- changes to the physical environment that make more active forms of transport a more attractive choice

There was also inconclusive evidence for the impact of a further intervention- integrating small amounts of activity into a school or work day. This is an area that would benefit from further research.

Stair prompts show evidence of increasing stair use, but the increase is greater in studies where the alternative is an escalator when compared to an elevator.

Soler et al., (2010) conducted a systematic review on the impact of point-of-decision prompts for stair use. The review included 16 studies which focused on two approaches to promote the use of stairs: 1) point-of-decision prompts and 2) prompts plus enhancing the environment in stairwells (music, painting walls, and artwork). The review concluded that point-of-decision prompts were effective in increasing stair use. However, there was no research at the time of the review to support the effectiveness of stairwell enhancements and stair use.

The impact of choice prompts on activity was also assessed by Lewis and Eves (2012) after implementing a multi-component stair climbing intervention. The intervention was conducted in a tram station in the UK where signs were posted encouraging people to use the stairs. In the first week, a single sign was placed at the bottom of the stairs noting, "*Regular stair climbing helps to prevent weight gain*". Two weeks after this sign was posted, a second sign was added at the top of the stairs saying, "*Well done stair climbers! You have just burned a 16th of the calories needed to avoid weight gain.*" The authors observed the results of four different scenarios in order to assess the setting at baseline and the impact of the signs alone and in combination. The results obtained through observation of 38187 pedestrians revealed that stair climbing increased when both messages were used.

The grey literature suggests that stairs should be made more prominent and appealing so people are more likely to be attracted to these as opposed to elevators or escalators (Marteau et al, 2001 cited in Bailey and Harper, 2015).

The inclusion of small bouts of physical activity during the day in schools, worksites and other locations may be a promising approach for increasing physical activity but findings were inconclusive.

Barr-Anderson et al. (2011) conducted a systematic review to investigate the impact of interventions designed to improve physical activity levels by introducing small bouts of physical activity to a routine day. The systematic review consisted of 40 studies highlighting findings related to interventions implemented in schools (n=28) or worksite (n=12) and with sample sizes ranging from 28 to 1914. School and worksite-based interventions most commonly involved the integration of 10 minute bouts of physical activity during the day or 10-15 minute physical activity breaks. The results of this review revealed that half of all school-based studies and half of all worksite-based studies found an association with improved levels of physical activity – findings were therefore inconclusive. Work and school based approaches to increasing physical activity variations of interventions, and how they may alter employees and students physical activity levels, should be further explored.

The grey literature found that altering the local environment to offer alternatives to motorised transport can increase physical activity.

Edwards and Tsouros (2006) state that improving walking routes that have a mixture of shops, schools, workplaces and other habitable places increases the amount that people walk, while increasing cycle lanes and cycle hire schemes could also be effective in encouraging more people to use these rather than other motorised forms of transport. Thus "*neighbourhood design, the location of schools and businesses and how, local leaders assign priority to cars, cyclists and pedestrians all affect people's ability to engage in physical activity and active living*" (Edwards and Tsouros, 2006, pg.3).

4 Conclusion

The findings of this review demonstrate the complexity of the evidence for specific drivers of energy balance-related behaviours (dietary behaviour and physical activity). The evidence for specific drivers of consumer point-of-decision prompts (via choice architecture/nudging) on consumer food purchasing and dietary patterns. There are significant gaps in our knowledge and understanding of energy balance (how both physical activity *and* diet impact weight loss, weight gain, and maintenance of weight loss) and the effectiveness of strategies to improve the behaviours contributing to energy balance.

For example, most of the peer-reviewed studies considered one behaviour (dietary or physical activity-related) and the impact on BMI; only one study was found that examined the combined effect of dietary behaviours and physical activity on BMI. This is largely due to the practical considerations of studying both behaviours in the same study – it is time, labour and resource intensive. However, it is vital that studies examining both behaviours, and their effect on obesity over time, are commissioned and funded to provide robust evidence to guide policy and practice. A wider discussion of the challenges of investigating complex and multivariable issues like obesity and physical activity, within the confines of a classical RCT design, may therefore be of interest for academics and policy-makers interested in evidence-based policy. Such a discussion would also benefit from input from research design experts to explore alternative study designs beyond RCTs.

The review also indicates a need for more research about the use and effectiveness of choice architecture/nudging interventions to increase physical activity or increase healthy dietary behaviours. At present, there is much more information available about the use of nudging interventions to improve dietary behaviour when compared with physical activity. However, there is still need for research that can demonstrate effectiveness of these nudging interventions within more diverse samples and across different settings (e.g., schools, communities, varying age groups).

Behaviours contributing to energy balance. Looking specifically at the associations between dietary behaviours or physical activity and BMI, the review found mixed results. Findings regarding the associations between dietary behaviour and BMI suggest that dietary behaviours vary geographically, which may be attributable to socio-economic differences across regions and differences in cultural norms regarding food consumption. These variations can also be explained by availability of particular foods, such fruit juice, snacks, SSBs, and vegetables and their associated consumption patterns across socio-economic groups. Results looking at physical activity also showed that significant associations between physical activity or screen time and BMI were not consistent across the EU countries studied. Authors of the research suggest that social and physical environmental factors may also provide an explanation for the differences observed, but the use of self-report measures rather than objective measures may also explain this inconsistency. These findings also illustrate the need for data that allows for comparison of energy balance related behaviour across the European Union and suggests that the obesity epidemic, although attributable to energy imbalance, may not have universal causal factors. Public health strategies to tackle obesity may need to be tailored according to the target population. Lastly, while the impact of SES on EBRBs needs more investigation, it appears that low SES populations may be more likely to engage in behaviours that contribute to positive energy balance, highlighting a need for more research that focuses on these high risk groups, and utilises culturally appropriate methods to gain a deeper understanding of how healthier behaviours can be promoted and adopted within these populations.

Drivers of Behaviour. The review confirmed there are multiple factors/drivers that can influence dietary behaviours and physical activity, with varied and complex interplay. The drivers identified ranged from those linked to access (e.g., availability, affordability and transportation), social and physical environments (e.g., social support, culture, number of opportunities for physical activity or healthy food shopping) and individual characteristics (gender, taste preference, perceived benefit of healthy eating or physical activity). Socio-economic status was also identified as an important factor. Income was particularly relevant, with EU-level evidence in that the cost was found to be the most important factor in choice when buying food, rather than knowledge of healthy diet. In addition, both income and education were found to influence physical activity behaviours. These are commonly recognised drivers of behaviour, but there is a major gap in what interventions have been, and can be, implemented on a large-scale to create an environment that is more conducive to making healthy choices affordable, accessible, and the 'easy' choice to make.

Nudging to make behaviours healthier. There was evidence that nudging interventions can be effective in improving dietary behaviours. Systematic reviews, meta-analyses and sources from the grey literature showed that building nudging techniques into nutrition labelling (e.g. by highlighting healthier alternatives or using visual colourful cues to influence colours) in particular shows some evidence of impacting food choice and potentially consumption. However, some of the studies suggest that the labels did not influence all consumers, mainly those who were already looking for the healthiest option. Product placement approaches were also shown to offer promise in terms of impacting on consumer behaviour, but there is a need for high-quality studies that quantify the magnitude of positional effects on food choice in conjunction with measuring the impact on food intake, particularly in the longer term. There was some evidence that increasing availability of healthy foods and incentivizing healthy items through lower costs within institutional settings can, at minimum, increase selection of healthy foods and potentially reduce the consumption of less healthy foods. In terms of nudging physical activity, stair prompts are the most commonly researched area to date. We found some studies indicating that prompts can increase stair use. In the case of stair prompts, the systematic review included in this report concluded that it was not possible to determine evidence that enhancing the environment in stairwells (i.e., music, artwork, carpet and painting walls) was effective in increasing use, and noted the need for additional research on the contribution of stair use to overall physical activity. Other nudging strategies that could be effective in influencing physical activity levels (e.g. changing the physical environment to encourage walking) would benefit from further research and exploration.

Annex 1 Peer-reviewed literature review methodology

This sub-section describes the approach taken 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 A1. 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 above stated topics, the literature review was conducted around the following agreed upon questions.

- What behaviours contribute to positive energy balance?²²
- What are the main drivers for food purchasing, cooking and eating (and eating together) and physical activity choices?
- How can these choices/behaviours be efficiently framed or nudged so as to become healthier?

The findings from the fourth 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 minimize bias, the literature search approach included identification of a priori search parameters (also considered first level inclusion and exclusion criteria) to 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.

²² This question was added to the original list of research questions developed by DG SANTE in order to further examine the evidence about behaviours contributing to positive energy balance which were not emerging from searches. Literature searches specific to the behaviours associated to positive energy balance were conducted as part of the peer-reviewed literature only.

A1.2.1 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 3 research questions. Literature searches were conducted in PubMed, EBSCO (CINAHL, ERIC, PsycInfo), Embase, and SPORTDiscus. 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:
<ul style="list-style-type: none"> Published between 1/1/2005-5/31/2016 	<ul style="list-style-type: none"> Articles published before 1/1/2005
<ul style="list-style-type: none"> Peer-reviewed scientific publications <ul style="list-style-type: none"> - Original research - Systematic reviews - Meta-analyses - Human focused research 	<ul style="list-style-type: none"> Editorial comments/commentaries <ul style="list-style-type: none"> - Dissertations - Theses - Opinion articles - Animal focused research
<ul style="list-style-type: none"> Article published in English, French, German, Italian Polish and/or Spanish 	<ul style="list-style-type: none"> 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 three groups of publications for screening for A1. After the searches, the results were reviewed to ensure they accurately met search parameters and duplicates were removed for screening in Stage 2.

A1.2.2 Stage 2: Screening search results (title and abstract) for relevance

At Stage 2, 2 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.

A4.1.1.1 Stage 2 Level 1 Initial Screening (Quality check)

Search hits from all databases searched in Stage 1 were grouped by the 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.²³

A4.1.1.2 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 2 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 ²⁴	Articles published before 1/1/2005
Publication Type	Peer-reviewed scientific publications <ul style="list-style-type: none"> - Original research - Systematic reviews - Meta-analyses - Human focused research 	<ul style="list-style-type: none"> • Editorial comments/commentaries • Dissertations • Theses • Opinion articles Animal-focused research • 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	<ul style="list-style-type: none"> • Studies conducted in America, Australia, Canada, European Countries, Great Britain, Mexico or Brazil²⁵ 	<ul style="list-style-type: none"> • Studies in all other countries
Human subject	<ul style="list-style-type: none"> • Human-focused research 	<ul style="list-style-type: none"> • Animal-focused research
Behavior/ Outcome	<ul style="list-style-type: none"> • Studies specific to how a behaviour (e.g. nutrition, physical 	<ul style="list-style-type: none"> • Specific to the assessment of methods for measuring of behaviours contributing

²³ 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.

²⁴ 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.

²⁵ Note that systematic reviews could have references including other countries. Also ad hoc searches conducted post screening to supplement screened literature may have included other countries.

Stage 2 – Level 2		
	activity, SSB consumption, fast food consumption, physical activity) contributes to energy balance or healthy weight OR <ul style="list-style-type: none"> • Studies specific to an outcome of interest: overweight/obesity, academic performance, school performance, etc. 	to energy balance (e.g., assessing the validity of self-reported physical activity or dietary behaviours, methods for assessing dietary or physical activity behaviours) OR <ul style="list-style-type: none"> • Specific to methods for assessing outcomes (e.g., measure of obesity)
General population	<ul style="list-style-type: none"> • Studies where the population of focus includes children, adults or older adults in the general population 	<ul style="list-style-type: none"> • Studies where the population of focus is a narrow population such as critically ill, hospitalized patients, people with a chronic condition or terminal illness, those incarcerated, etc.
Weight Status/ BMI	<ul style="list-style-type: none"> • Studies that examine the association of behavior with weight status or BMI²⁶ 	<ul style="list-style-type: none"> • Studies that examine the association of behavior with metabolic indicators (adiponectin, ghrelin, LDL, etc.), environment or genetics

From 600 publications screened in Stage 2, 77 publications were deemed of potential relevance, coded as “Include” and selected for full article review after Stage 2 screening.

A1.2.3 Stage 3: Full Article Review and Synthesis

77 publications were exported for review of full text in this A1 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, 50 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.

²⁶ The team agreed that as a proxy for BMI articles with other measures of BMI, such as respiratory factors, heart rate, or skin fold measures could have been included as well.

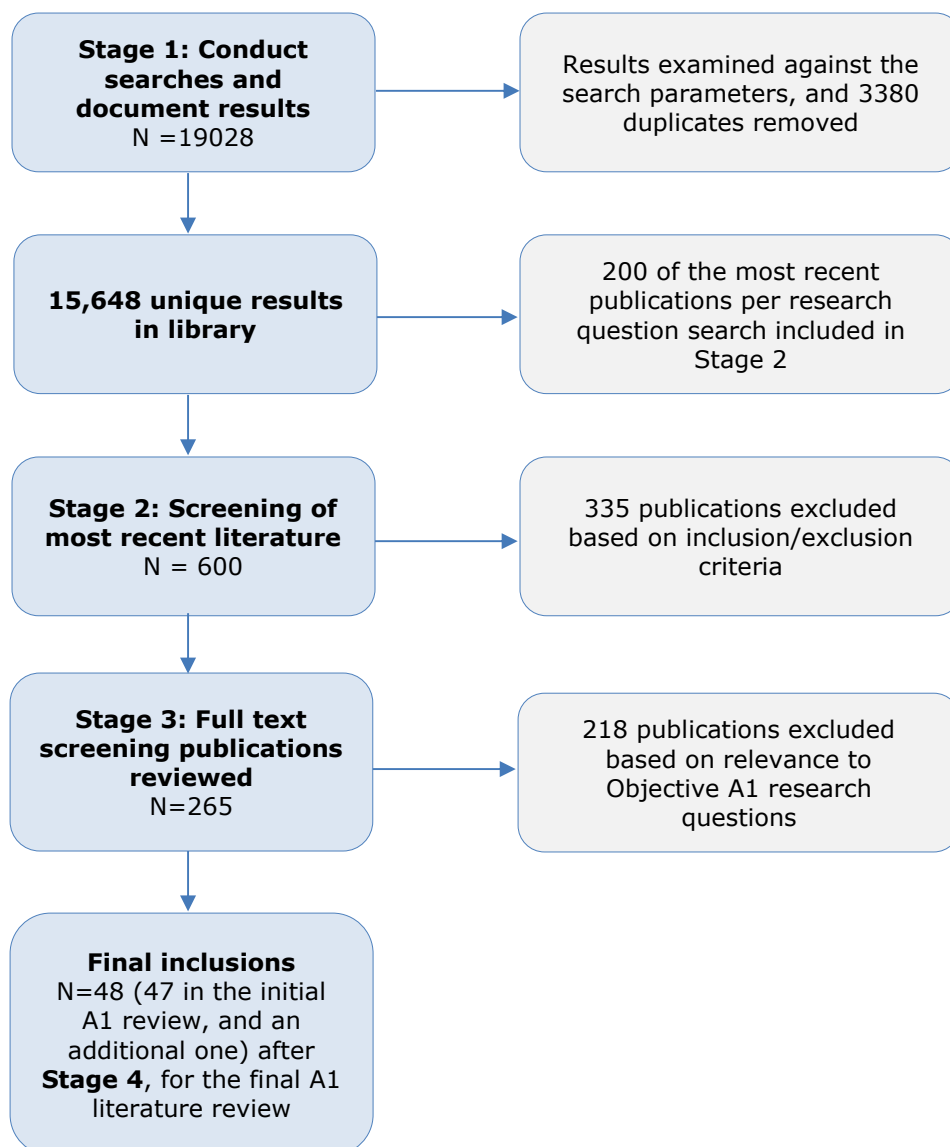
A1.2.4 Stage 4: External expert reviews and input

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, one additional reference was screened and incorporated into the reviews.

A1.2.5 Number of included and excluded publications

Figure 3 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 48 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 3. Diagram showing number of included and excluded publications at each stage – peer reviewed literature



As shown in Figure 3, a total of 19,028 search hits were retrieved. A total of 3380 duplicates were found and removed from the search hits resulting in 15,648 search results for A1. From the 15,648 articles, the team screened 600 of the most recent titles and abstracts (200 for each of the three research questions, to create a manageable amount of material within the resources for the study; and on the premise that the most recent material was most relevant science). From the 600 most recent titles and abstracts screened 265 were deemed of potential relevance and reviewed as full texts. From the 265 deemed relevant and reviewed as full texts 48²⁷ publications were selected for inclusion, in this final review.

²⁷ The full list of references included from the peer-reviewed literature can be found in Annex 3 and includes one additional publication recommended by the external expert review panel

Annex 2 Peer-reviewed literature search terms

Objective A1 Search Terms: Behaviours Contributing to Positive Energy Balance

Rules:

- Include 2005 or later
- Include databases: Pubmed, EBSCO (CINAHL, ERIC, PsycInfo), Embase and SPORTDiscus
- Include human-focused only (exclude animal studies)
- Include only peer-reviewed literature and narrative reviews
- Exclude non-relevant subheading in PubMed/Embase

RQ1: What factors contribute to positive energy balance?

Primary Term		Combined with:	
"Metabolic syndrome"	[tiab]	Predictors	[tiab]
"Overweight"	[tiab]	"Physical activity"	[tiab]
"Obesity"	[tiab]	Diet	[tiab]
"Adiposity"	[tiab]	"Dietary behavior"	[tiab]
"Body Mass Index"	[tiab]	Nutrition	[tiab]
"Abdominal fat"	[tiab]	Eating	[tiab]
"Waist-hip ratio"	[tiab]	"Exercise"	[tiab]
"Waist Circumference"	[tiab]	"Risk factors"	[mh]
"Energy balance"	[tiab]	"Exercise"	[mh]
Obese	[tiab]	Diet	[mh]
Obesity	[mh]	Eating	[mh]
"Metabolic diseases"	[mh]		
Body Mass Index	[mh]		

RQ1a: What are the main drivers of food shopping?

Primary Term		Combined with:	
"Food shopping"	[tiab]	"Environmental factor"	[tiab]
"Food choice"	[tiab]	"Environmental factors"	[tiab]
		"Healthy eating"	[tiab]
		"Household factor"	[tiab]
		"Household factors"	[tiab]
		"Importance of cost"	[tiab]
		"Importance of nutrition"	[tiab]
		"Importance of taste"	[tiab]

	"Individual factor"	[tiab]
	"Individual factors"	[tiab]
	Convenience	[tiab]
	Barriers	[tiab]
	Cost	[tiab]
	Factor*	[tiab]
	Predictor*	[tiab]
	Time	[tiab]
	"Social environment"	[mh]
	Costs and cost analysis	[mh]
	Socioeconomic factors	[mh]
	Taste	[mh]
	"Social environment"	[tiab]
	"Socioeconomic factors"	[tiab]
	taste	[tiab]

RQ1b: What are the main drivers of cooking?

Primary Term

Combined with:

Cooking	[tiab]	"Environmental factor"	[tiab]
"Preparing meals"	[tiab]	"Environmental factors"	[tiab]
Cooking	[mh]	"Healthy eating"	[tiab]
		"Household factor"	[tiab]
		"Household factors"	[tiab]
		"Importance of cost"	[tiab]
		"Importance of taste"	[tiab]
		"Importance of nutrition"	[tiab]
		"Individual factor"	[tiab]
		"Individual factors"	[tiab]
		"Social environment"	[tiab]
		"Socioeconomic factors"	[tiab]
		Barriers	[tiab]
		Convenience	[tiab]
		Cost	[tiab]
		Factor*	[tiab]
		Predictor*	[tiab]
		Taste	[tiab]
		Time	[tiab]
		"Social environment"	[mh]
		Costs and Cost Analysis	[mh]
		Socioeconomic factors	[mh]
		Taste	[mh]

RQ1c: What are the main drivers of eating?

Primary Term		Combined with:	
Eating	[tiab]	"Environmental factor"	[tiab]
"Dietary behavior"	[tiab]	"Environmental factors"	[tiab]
"Food consumption"	[tiab]	"Healthy eating"	[tiab]
Eating	[mh]	"Household factor"	[tiab]
		"Household factors"	[tiab]
Diet	[mh]	"Importance of cost"	[tiab]

	"Importance of nutrition"	[tiab]
	"Importance of taste"	[tiab]
	"Individual factor"	[tiab]
	"Individual factors"	[tiab]
	"Social environment"	[tiab]
	"Social environment"	[mh]
	"Socioeconomic factors"	[tiab]
	Barriers	[tiab]
	Convenience	[tiab]
	Cost	[tiab]
	Costs and cost analysis	[mh]
	Factor*	[tiab]
	Predictor*	[tiab]
	Socioeconomic factors	[mh]
	Taste	[tiab]
	Taste	[mh]
	Time	[tiab]

RQ1d: What are the main drivers of physical activity?

Primary Term		Combined with:	
"Physical fitness"	[mh]	"Environmental factor"	[tiab]
"Physical endurance"	[mh]	"Environmental factors"	[tiab]
"Leisure activities"	[mh]	"Healthy eating"	[tiab]
Exercise	[mh]	"Household factor"	[tiab]
"Physical activity"	[tiab]	"Household factors"	[tiab]
"Exercise"	[tiab]	"Importance of cost"	[tiab]
Walking	[tiab]	"Importance of nutrition"	[tiab]
"Leisure time activity"	[tiab]	"Importance of taste"	[tiab]
"Leisure activity"	[tiab]	"Individual factor"	[tiab]
"Physical fitness"	[tiab]	"Individual factors"	[tiab]
"Physical endurance"	[tiab]	"Social environment"	[tiab]
"Active lifestyle"	[tiab]	"socioeconomic factors"	[tiab]
		Convenience	[tiab]
		Cost	[tiab]
		Barriers	[tiab]
		Factor*	[tiab]

	Predictor*	[tiab]
	Taste	[tiab]
	Time	[tiab]
	"Social environment"	[mh]
	Costs and cost analysis	[mh]
	Socioeconomic factors	[mh]
	Taste	[mh]

RQ2a: How can dietary behaviour be nudged so as to become healthier?

Primary Term		Combined with:
Eating		"Policy strategy" [tiab]
"Dietary behavior"		"Policy strategies" [tiab]
"Food consumption"		"Policy intervention" [tiab]
"Beverage consumption"		"Policy interventions" [tiab]
"Sugar sweetened beverage consumption"		"Environmental strategies" [tiab]
		"Environmental change strategies" [tiab]
"Food shopping"		"Environmental change strategy" [tiab]
"Food choice"		"Environmental interventions" [tiab]
Cooking		Nudge [tiab]
"Preparing meals"		"Behavioral economics" [tiab]
"Healthy eating"		"Evidence-based" [tiab]
Eating		Nutrition policy [mh]
Cooking		Economics, Behavioral [mh]
Diet		

RQ2b: How can physical activity behaviour be nudged so as to become healthier?"

Primary Term		Combined with:
"Physical Activity"	[tiab]	"Policy strategy" [tiab]
"Exercise"	[tiab]	"Policy strategies" [tiab]
Walking	[tiab]	"Policy intervention" [tiab]
"Leisure time activity"	[tiab]	"Policy interventions" [tiab]
"Leisure activity"	[tiab]	"Environmental strategies" [tiab]
"Physical fitness"	[tiab]	"Environmental change strategies" [tiab]
"Physical fitness"	[mh]	"Environmental change strategy" [tiab]
"Active lifestyle"	[tiab]	"Environmental interventions" [tiab]
"Physical endurance"	[mh]	
"Physical endurance"	[tiab]	

"Leisure activities"	[mh]		Nudge	[tiab]
Exercise	[mh]		"Behavioral economics"	[tiab]
			"Evidence-based"	[tiab]
			Economics, Behavioral	[mh]

Annex 3 Peer reviewed literature bibliography

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Annex 4 Grey Literature review methodology

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 A1, were agreed upon in the inception phase (Table 4). The main key words were either specific to the objective or broader thematic terms; for objective A1 the main key words included both 'nutrition' and 'point of sale promotion'. A second list of search terms was also used – these combination words were used to guide the search and produce the most relevant results; i.e. for Objective A1, the key word 'active living' would be combined with the broader term 'motivations'.

Table 4. Search terms used for objective A1 grey literature review

Suggested Search Parameters	
Parameters	
<ul style="list-style-type: none"> • Grey literature • Published in English, French, German, Italian, Polish and/or Spanish • Date range (1995 – 2016) 	
Key Words and suggested Combinations of Search Terms	
Key Words	Combined With

Suggested Search Parameters

Nutrition	Biological determinants: hunger, appetite, taste
Healthy eating	Motivations
Healthy diet	Behavioural economics
Physical (in)activity*	Nudge theory
Active living	Food choices
Exercise	Consumption
Grocery shopping	Environmental conditions: product placement, default options, external cues, container size)
Food shopping	Food marketing
Preparing meals	Behavioural influencers: friends, family, peers, culture
Families	Marketing and advertising
(un)healthy	Information
Food labelling/menu labelling	Regulation
Food advertising	Taxation
Point of sale promotion	Reformulation
Healthy eating media (or promotion)	Setting type (e.g., childcare/early care, school, community) Physical environment
Physical activity media (or promotion)	Physiological determinants
Exercise media (or promotion)	Psychological determinants: mood, stress, anxiety Physical determinants: access, education, skills, time
Junk food tax	Socio-economic terms: living conditions, employment, poverty, low income
Junk food ban	
Competitive food ban	External economic determinants: cost, income, availability of food
Fast food ban	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. behavioural economics)

were enclosed in quotation marks (e.g. 'behavioural economics') 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
- Opengrey.org
- WHO websites
- Kings Fund

The King's Fund, Opengrey.org, WHO and the European Commission yielded the most results for Objective A1. The grey literature search was a fluid and dynamic process. As a result, keywords set out in the inception report such as 'Junk Food Ban' were rephrased (e.g. to 'bans on eating junk food') to improve the searching, and subsequent extraction process. Suggestions of other key words were made, by the grey literature review team or DG Health and Food Safety reviewers after the initial key word searches for Objective A1. As a result, supplementary searches were carried out for additional key words. In addition, search results from other objectives that were relevant were included.

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. For example, in objective A1, phrases such as "sedentary behaviour AND motivations for exercising" were used to ensure that highly-focused and relevant search results were generated for the original key words, in this case, 'sedentary behaviour' and 'exercise'. All hand searches for this objective were completed on Google and Search Europa.

A4.3 Stage 2: Screen Search Results for Relevance

Most databases, search engines and websites offered the use of a relevancy filter²⁸ 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 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 335 results from the searching for objective A1 were saved into the library.

²⁸ '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.

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
<ul style="list-style-type: none"> • Published between 1995-2016 • Government reports from European Commission, European Parliament and EU Member States. • Think tank reports/publications • Academic papers, conference papers and abstracts • Bibliographies • Programme evaluation reports²⁹ • Standard/best practices documents • Policy initiatives at European and/or national level- run by governments, not-for profit organisations • 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). • Primary theme/focus is human nutrition and physical activity • Publication available via accessible databases • Published in English, French, German, Italian, Polish and/or Spanish • Theses and dissertations (post-2011 only) 	<ul style="list-style-type: none"> • Published or enacted prior to 1995 • Non-nutrition and physical activity themed/focused • Industry-produced publications • Industry-produced project evaluation reports • Industry-produced good practice reports • Publications focusing on animal nutrition and physical activity • Blog or personal think thought pieces • Newsletters or news articles • Theses and dissertations (2010 and older)

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, unless the report was deemed very relevant.

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

²⁹ 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

A4.4.1 Exclusion based on quality checklist

The quality check was based on the AACODS checklist (AACODS)³⁰ 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?

The remaining grey literature was examined further so that only results relevant to the objective were finally extracted. In particular, each article was examined for text relating to the key terms and questions under the objective. For example, in objective A1 the text was examined for reference to the research question “what are the main drivers for food shopping, cooking and eating (and eating together) and physical activity choices?” as well as the overall objective.

A4.5 Stage 4: Extraction of full texts

A data extraction template in Excel was used to capture the following categories of information: 1) identifying information for each publication, 2) study design 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. In total, 81 results were extracted.

A4.6 Stage 5: Review of full texts and final screening process

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, 45 results were excluded.

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.

³⁰ Please see the full outline of the AACODS checklist here:
https://dspace.flinders.edu.au/jspui/bitstream/2328/3326/4/AACODS_Checklist.pdf

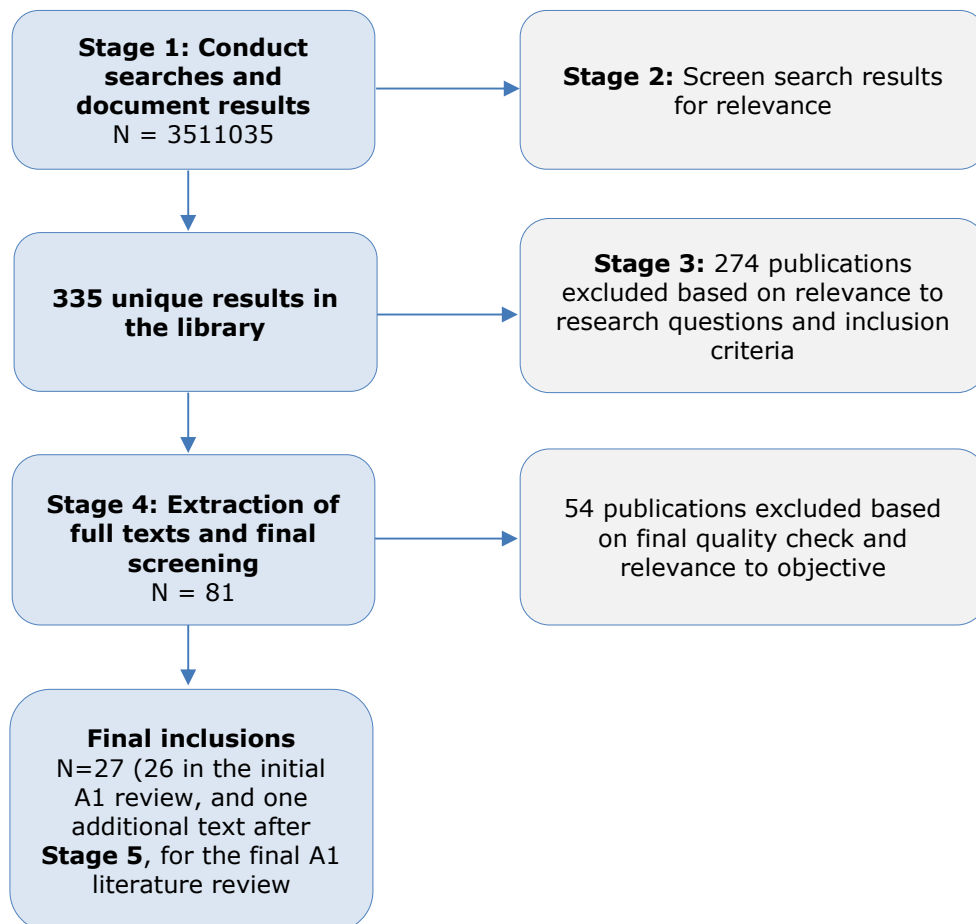
A4.7 Stage 6: External expert reviews and input

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, one additional reference was screened and incorporated into these reviews.

A4.8 Number of included and excluded references

The diagram in Figure 4 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 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 – grey literature



As shown in Figure 4, a total of 335 search hits were retrieved and saved for A1. From the 335 results saved in the library, 274 were excluded based on the relevance to Objective A1 research questions. Following this, 81 results were extracted fully. An additional 54 publications were then excluded based on inclusion/exclusion criteria, quality of evidence and relevant to the research questions. In Stage 5, supplementary searches were conducted and/or articles recommended by experts during the workshops were looked and one additional relevant reference proposed by external experts was included.

A4.9 Grey literature bibliography

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