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A guide to the dietary data in eight CLOSER studies

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Preface

CLOSER (Cohort & Longitudinal Studies Enhancement Resources) aims to maximise the use, value and impact of longitudinal studies, both at home and abroad. Bringing together eight leading studies, the British Library and the UK Data Service, CLOSER works to stimulate interdisciplinary research, develop shared resources, provide training, and share expertise. In this way CLOSER is helping to build the body of knowledge on how life in the UK is changing – both across generations and in comparison to the rest of the world.

CLOSER's research includes a number of work packages focused on retrospective harmonisation, their aim being to make the data from different longitudinal studies more comparable in order to find out how life in the UK is changing from generation to generation. This documentation was produced as part of CLOSER work package 17: CLOSER Work Package 17: 'Scoping existing dietary data available in CLOSER to support cross-cohort research questions'.

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1 Introduction

1.1 The Cohort and Longitudinal Studies Enhancement Resources (CLOSER)

The Cohort and Longitudinal Studies Enhancement Resources (CLOSER)[1] is funded by the Economic and Social Research Council (ESRC) and Medical Research Council (MRC). The main aims of the CLOSER consortium are to provide effective collection, integration and use of data in longitudinal studies. A CLOSER data resource profile has been published in the International Journal of Epidemiology [1].

The CLOSER consortium was established in 2012 in partnership with the following longitudinal studies:

- Hertfordshire Cohort Study (HCS)
- MRC National Survey of Health and Development (NSHD)
- 1958 National Child Development Study (NCDS)
- 1970 British Cohort Study (BCS70)
- Southampton Women's Survey (SWS)
- Avon Longitudinal Study of Parents and Children (ALSPAC): *Children of the 90s*
- Millennium Cohort Study (MCS): *Child of the New Century*
- Understanding Society: The UK Household Longitudinal Study (UKHLS)

1.2 Why study diet in cohort and longitudinal studies?

Diet is a major modifiable health behaviour that can impact a wide variety of health outcomes [2]. The studies in the CLOSER consortium provide a resource in which both drivers and consequences of dietary intake can be explored. Together they also provide opportunities to examine longitudinal and secular trends in dietary intake. However,

[1] https://www.closer.ac.uk/

measuring diet is not straightforward. An individual's diet is the result of complex social, economic and cultural circumstances [3-6] and dietary intake will vary according to age, season, day of week, and working patterns, and it has considerable random variation [7]. The nutrient composition of foods themselves can also vary depending on soil composition, fortification practices and changes in manufacturing [6]. Further, measurement error and potential reporting bias can lead to under- or over-estimation of associations between diet and health. [6].

Nutritional epidemiology has been criticised [8]. Findings of associations from particular diet-related variables and health from observational studies are often not replicated in randomised controlled trials (RCTs). It is suggested that this is due to residual confounding, measurement error, and the fact that capturing dietary intake is too complex for questionnaire methods [8]. However recently there have been significant improvements in the validity of dietary assessment methods. Further, despite RCTs being the gold standard study design in many instances they are not always suitable for nutrition; it is unethical to assign individuals to an inadequate nutrient level and difficult to capture the effects of long-term overall diet [9]. So, while no current dietary assessment method is able to measure diet exactly, understanding how diet is assessed in each of the original eight CLOSER studies, what data were collected, and undertaking cautious interpretation of results can support the use of these data.

1.3 Overview of this guide

This guide aims to provide guidance on the definition, measurement and interpretation of the dietary data collected in the CLOSER studies. It is intended to support researchers in the use of the dietary data both within single studies and across the studies. The guide is limited to describing dietary intake data and does not include information about eating behaviours, eating difficulties, food expenditure, biomarkers of nutrition or analytical methods. Details about the overall concept of dietary patterns and how they are constructed can be found elsewhere [10]

Before detailing how dietary assessment was conducted and how it has been used for research in each of the studies, a brief overview of contextual and policy considerations and a summary of dietary assessment tools is presented.

1.4 Dietary research in context

The studies included in CLOSER embody over seventy years of history and changing public health policy in the UK. It is important to understand the broader context at the time when using the dietary data in these cohorts.

Nutritional science is a relatively new discipline with the first vitamin being isolated and chemically defined in 1926. In the early years, the focus of nutritional science was on the identification of specific nutrients and their role in deficiency diseases like scurvy (vitamin C), rickets (vitamin D) and goitre (iodine). On the back of these successes, this approach was extended to identify single nutrients that were related to non-communicable diseases. This reductionist method led to the development of nutrient-based guidelines in the 1980s, e.g. recommendations to reduce fat intake. More recent advances have identified that the impact of nutrition on health and non-communicable diseases is far more complex than a single nutrient approach and to fully understand it, foods and dietary patterns rather than single nutrients should be explored. A full history of nutritional science can be found in previous publications [11-13].

There are nutrition-related events in UK-history that the researcher should also be mindful of when using the dietary data in longitudinal/CLOSER studies e.g. rationing in the 1940s, an increase in kitchen-appliances and a return of women back into the workforce in the 1980s, and promotion of healthy eating from 1980s. Some of these are outlined in Table 0.1 taken from the detailed paper published by the British Nutrition Foundation in 2007 [14].

Table 0.1 Timeline of diet-related events in the UK

(Taken from [14])

Decade	Political/societal events	Nutritional reports/regulations
1940s	Second World War (1939–1945); WFS introduced (1940); Rationing begins (1940); Labour Government (1945); Heathrow airport opens (1946); First self-service supermarket opens (1947); National Health Service established (1948)	Mandatory fortification of margarine with vitamins A and D began (1942); National Food Survey established (1940); Nutritional standards for school meals introduced (1941); First Food Labelling Order (1944)
1950s	Conservative Government (1951); London smog (1952); Watson and Crick publish the structure of DNA (1953); End of rationing (1954); Treaty of Rome establishes EEC and CAP (1957); 24% of households own a fridge	Nutritional allowances set by BMA (1950)
1960s	31% of households owned one or more cars (1961); Labour Government (1964); Eligibility of WFS was restricted to those who received some form of benefit (1968)	Bread and Flour regulations (1963); Launch of the first margarine rich in polyunsaturated fatty acids (1964); British Nutrition Foundation established (1967); COMA established (1968); Recommended Nutrient Intakes set by COMA (1969)
1970s	General Household Survey started (1970); Conservative Government (1970); Decimalisation (1971); Energy crisis (1973); 3-day week (1973); Labour Government (1974); UK accession to EEC and became part of CAP (1973); Drought (1975/76); Conservative Government (1979); 40% of households own a freezer (1979)	Burkitt hypothesis – emphasis switching to preventative nutrition (1972); COMA report on Diet and Heart Health (1974); Recommended Daily Amounts set by COMA (1979)

Decade	Political/societal events	Nutritional reports/regulations
1980s	The Black report highlights inequalities in health (1980); Andreisson CAP reform introduces milk quotas and voluntary set-aside (1987/88); Salmonella food scare (1988); 50% of households own a microwave	Food-based guidelines replace nutritional standards for school meals (1980); NACNE report published (1983); COMA report on Diet and Cardiovascular Disease (1984); Introduction of foods with a healthier nutritional profile, e.g. low fat, reduced sugar (1985); COMA report on Dietary Sugars and Human Disease (1989)
1990s	Health of the Nation published (1992); Nutrition Taskforce set up (1992); MacSharry CAP reform (1992); Fairtrade foundation established in UK (1992); BSE food scare (1995/6); Labour Government (1997); 72% households owned one or more cars (1998); Saving Lives – Our Healthier Nation published (1999); Policy Action Team report 13 published citing problems of poor food access in low income neighbourhoods (1999)	Dietary Reference Values set by COMA (1991); COMA report on the Nutritional Aspects of Cardiovascular Disease(1994); Folic acid labelling scheme introduced (1997); WCRF report (1997); COMA report on the Nutritional Aspects of the Development of Cancer (1998)
2000s	FSA established (2000); EU enlargement (2004); National School Fruit and Vegetable scheme rolled out across primary schools (2004); Choosing Health – Making Healthier Choices Easier published (2004); Healthy Start scheme launched to replace the WFS (2006); School Food Trust established (2006)	COMA report on Folic Acid and the Prevention of Disease (2000); Establishment of SACN (2000); Reintroduction of nutritional standards for school meals (2001); SACN report on Salt and Health (2003); SACN report on Folate and Disease Prevention (2006); DH Healthy Living Strategy introduced (2007)

Notes: BMA: British Medical Association; CAP: Common Agricultural Policy; COMA: Committee on the Medical Aspects of Food and Nutrition; DH: Department of Health; EEC: European Economic Community; EU: European Union; FSA: Food Standards Agency; NACNE: National Advisory Committee on Nutrition Education; SACN: Scientific Advisory Committee on Nutrition; WCRF: World Cancer Research Fund; WFS: Welfare Food Scheme

2 Overview of dietary assessment methods

2.1 Dietary assessment tools (DATs)

In epidemiological research, diet is often assessed using dietary assessment tools (DATs). The aims of most DATs are to collect an accurate record of habitual food and nutrient intake for a group of individuals. This can be extremely difficult, particularly due to the significant variation in dietary intake within individuals. There has been extensive work in developing DATs. There are two online resources, both supported by the Medical Research Council, which give a comprehensive overview of DATs:

- Nutritools developed by the DIET@NET partnership[2]
- DAPA Measurement Toolkit developed by the University of Cambridge (also supported by the NHS, European Union and InterConnect Project)[3]

Each DAT has specific strengths and weakness and the one used should be suitable for the research question, overall study design and population of interest. The reliability and validity of these tools have been discussed in Willett (2013) [6] and guidance on use of DATs is given in the online resources listed above. Table 2.1 to Table 2.3 give a brief overview of the main DATs used in the original CLOSER partner studies, namely 24-hour recalls, food frequency questionnaires and diet diaries (information adapted from Willett and Nutritools.org [6, 15]).

[2] https://www.nutritools.org/
[3] https://dapa-toolkit.mrc.ac.uk/

Table 2.1 24-hour recall

Retrospective in-depth interview capturing everything the participant had to eat or drink over the past 24-hour period. This can be administered in person over the phone or online. There is opportunity to probe for additional foods and food preparation methods and to use prompts and aids for portion size estimation.	
Strengths	**Weaknesses**
Can provide detailed information as it is open ended. This provides good estimates of short-term intake of absolute intakes (good for when comparing when specific dietary recommendations)	Does not capture irregularly consumed foods
Provides data that can be analysed in different ways	Relies on good participant episodic memory
Can provide some contextual information depending on design e.g. who else was present when eating	Relies on recalled and estimated portion sizes
Useful for capturing intake in culturally diverse contexts	A single day is not representative of usual individual intake due to day-to-day variability (use of multiple 24-hour recalls over a sufficient number of non-consecutive days and seasons can overcome this)
Moderate participant burden and high compliance (depending on number of days)	A single day can under/over-estimate habitual intakes of certain nutrients from irregularly consumed foods
	When used in epidemiological associations, estimates may be attenuated as day-to-day variation is not accounted for
	Moderate to high researcher burden due to coding
	Can be expensive and time-consuming to code
	Forgotten items are common (exclusions) and intrusions (items included but were not consumed) also occur

Table 2.2 Food frequency questionnaires (FFQ)

Retrospective method where the participant reports frequency of usual consumption of a specific food/food group over a pre-defined period of time. Questions on quantity can also be included (semi-quantitative FFQ or fully-quantitative FFQ). The number of food/drink items included in the FFQ vary and can be long (comprehensive FFQ) or short. It can be administered in person or over the phone or self-completed on paper or online	
Strengths	**Weaknesses**
Can capture usual intake retrospectively	Precision of intake estimates is reduced
Can capture foods consumed irregularly	Information is limited to the food/food groups included in the food list; this can decrease cross-cohort comparison especially when diverse cultures are being compared
Can rank participants into intake levels	Short FFQs may not be reliable for total diet/nutrient intakes
If a long FFQ is used and portion size estimated, usual dietary intake and total nutrient intake can be estimated	Relies on good participant generic memory and literacy and numerical skills
Low participant burden so useful in large population studies	Needs careful design and validation in the population of interest as prone to misreporting
Low researcher burden as coding is less intensive than recall or diet diaries	

Table 2.3 Diet diaries

Prospective methods in which the participant records everything consumed over a number of days. It is best when these days include a mixture of weekend and week days. The amount of food/drink consumed can be estimated using household measures or weighed in the home. These diaries can include prompts and photographs to aid description of portion sizes and can be completed in paper format or online	
Strengths	**Weaknesses**
Provides detailed information on short-term intake leading to good estimates of total dietary/nutrient intake	Not suitable for retrospective study
Provides data that can be analysed in different ways	Does not capture irregularly consumed foods
Can provide some contextual information depending on design e.g. who else was present when eating	Potential for reactivity (changes of usual food choice) as number of days increases
Limits reliance on memory	Good literacy and numeracy skills needed
	Relies on participants to estimate portion sizes
	High participant burden, particularly as the number of days increases
	High researcher burden as coding can be complicated

2.2 Estimating nutrient intakes from DATs

Once dietary information has been collected using a DAT, nutrient intakes can be calculated. Some studies have used software for this process, and this will be discussed in the study-specific sections. A simplified overview of this process is depicted in Figure 2.1 and outlined in the steps below. The exact method depends on the DAT used.

2.2.1 Estimating nutrient intakes from 24-hour recalls and diet diaries

In general, the steps to extract nutrients from diet records are [6]:

1. Select a food composition database: It is important to use time and population appropriate food composition databases as manufacturers can change formulation of food products over time. It is also often necessary to use more than one source and refer to manufacturers' packets and recipe databases to code composite dishes e.g. lasagne.
2. Match foods listed in the DAT with entries in the food composition database. This can involve grouping different food items together.
3. If food/drinks are estimated in household measures, portion sizes in grams or standard units need to be allocated. This can be based on previously published standard portion sizes.
4. Calculate the nutrients based on the food composition database and portion size.
5. For unknown foods/groups or recipes where there is difficulty translating to appropriate food codes and/or weight, assumptions are often made with the input of a nutritionist/dietician.

2.2.2 Estimating nutrient intakes from FFQs

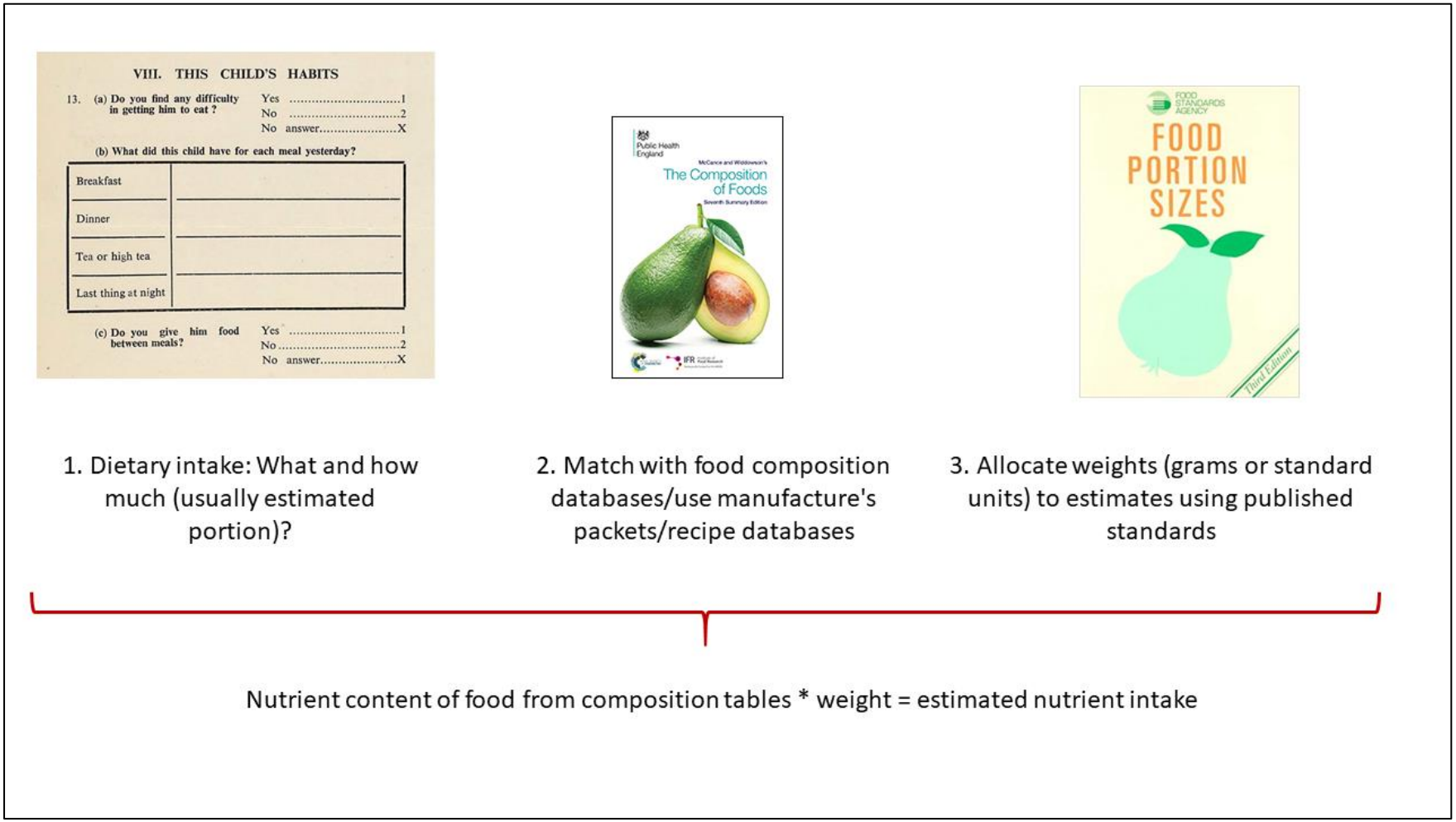
1. Select an appropriate food composition database (as above).
2. Match foods listed in the DAT with entries in food composition database
3. For FFQs that do not record amounts of foods, portion sizes need to be allocated (as above).

4. Allocate frequency weights based on responses; weight of each food/group consumed = frequency (e.g. 1.0 for once a day)*portion size
5. Total nutrient intake = ∑ (weight x nutrient content from food composition database)

In some cases, the nutrient content may be modified by responses to other questions, e.g. the brand of margarine used, or the type of cooking fat usually used or if fat is normally cut off meat.

Figure 2.1 Simplified representation of process to estimate nutrient intake from dietary assessment tools

Example of 24-hour recall is from the MRC National Survey of Health and Development



3 Overview of dietary information in selected CLOSER studies

Each of the original eight longitudinal studies in CLOSER have some information on dietary intake (Table 3.1). ALSPAC and SWS are highly focused on diet and include both FFQs and diet diaries. HCS, also focused on diet, collected dietary information primarily using FFQs. NSHD and BCS70 have collected dietary intake using diet diaries. NCDS, MCS and UKHLS have not used a traditional DAT (i.e. FFQ, diary or recall) but do have some diet-related questions.

Table 3.1 Summary of dietary information across selected CLOSER studies

Study	Year	Age	FFQ	Diary	Recall	Other*
NSHD	1950	4y			✓	
	1982	36y		✓	✓	
	1989	43y		✓	✓	
	1999	53y		✓		
	2006-2011	60-64y		✓		
	2014-2015	69y				✓
NCDS	1991	33y				✓
	2000	42y				✓
	2003	45y				✓
BCS70	1980	10y				✓
	1986	16y		✓		✓
	2000	30y				✓
	2012	42y				✓
	2016	46y		✓		
MCS	2001	9 months				✓
	2004	3y				✓
	2006	5y				✓

	2008	7y					✓
	2012	11y					✓
	2015	46y					✓
HCS	1998-2003	~66y	✓	✓			
	2011	~76y	✓† (Short FFQ)				
SWS‡	1998-2002	Before pregnancy	✓	✓			
		11 weeks gestation	✓	✓			
		34 weeks gestation	✓				
		6 months	✓	✓†	✓		
		12 months	✓	✓†			
		3y	✓	✓			
		6-7y	✓				
		8-9y	✓				
		11-13y	✓				
ALSPAC§	1991-1992	32 weeks gestation	✓				
	1991-1992	4 weeks		✓			
	1992-1993	4 months		✓†			
	1991-1993	6 months	✓				
	1992-1993	8 months		✓†			
	1992-1994	15 months	✓				
	1994	18 months		✓†			
	1994-1995	2y	✓				
	1995-1996	3y	✓				
	1996	3.5y		✓†			
	1996-1997	4y	✓				

	1997	5y		✓†		
	1997-1999	6-7y	✓			
	1998-2000	7y		✓		
	2000-2002	8-9y	✓			
	2002-2003	10y		✓		
	2004-2006	12-13y	✓			
	2004-2006	13y		✓		
UKHLS[|]	1991-2016					✓

* Diet-related questions
† Subgroup only
‡ Diet measured at multiple time points from both mothers and children
§ Diet measured at multiple time points from both mothers, partners and children
| Some dietary data collected throughout waves; some more detailed than others

4 Hertfordshire Cohort Study (HCS)

4.1 Summary of cohort

From 1911 until the National Health Service (NHS) was formed in 1948, records of birth weight, child illness, development and infant feeding were kept in Hertfordshire and summarised in handwritten ledgers [16]. By linking these records to mortality data through the NHS Central Register, Professor David Barker and colleagues were able to link markers of early experience to later health, most notably showing that lower birth weight was associated with increased risk of death from cardiovascular disease [17]. These initial studies that had included men and women born between 1920 and 1930 were followed by the Hertfordshire Cohort Study (HCS). Participants of the HCS included men and women who (a) were born 1931-1939, (b) had early life information from the ledgers, and (c) were still alive and registered with a General Practitioner in Hertfordshire between1998-2002 (traced using the NHS central registry). Approximately 3,000 men and women agreed to a home visit with a trained research nurse and a majority of them also completed a clinic

visit [16]. Sub-samples of these participants have also participated in a number of follow-up studies, principally focused on musculoskeletal outcomes.

The main objective of the HCS is to examine the interactions between genes, pre- and post-natal environments and adult diet and lifestyle behaviours in the aetiology of chronic disorders in later life [16].

4.2 Dietary data collection

Infant diet

The original Hertfordshire ledgers (from birth up to the first year of life) summarised information about infant feeding in the first year, including the type of milk feeding in infancy categorised as: breastfed only, bottle and breast-fed, or bottle-fed only. Records from individual home visits with more detailed information about type of feeding and duration were not retained [18].

Diet in adults

Information about dietary intake was collected during the baseline home visit (1998-2002) using a nurse-administered FFQ. The FFQ was modified from the European Prospective Investigation of Cancer (EPIC) questionnaire. This FFQ has been previously validated for use in a UK population [19]. The FFQ includes 129 food groups and foods and asks the participants to record the average frequency of consumption (never, <1/month, 1-3/month, 1/week, 2-4/week, 5-6/week, 1/day, 2-3/day, 4-5/day, ≥6/day) over the 3 months preceding the interview. The frequencies of consumption of foods not listed on the FFQ were recorded if they were consumed ≥1/week. Daily amounts of milk and sugar consumed were also recorded. Prompt cards listing example foods included in each food group were used to help standardise responses to the FFQ. At the end of the FFQ, participants were asked about their use of dietary supplements during the previous three

months. If they answered yes to using supplements, further details including the name and brand of the product as well as dose and frequency of use were requested. A total of 954 different dietary supplements were used by the cohort participants [20]. A shorter version of this FFQ was developed to assess diet quality in later data collections in Hertfordshire, including a sub-group of the participants in the East Hertfordshire follow-up (*n*=442) studies as part of a wider European project on osteoarthritis [21, 22].

24-hour food diaries were also collected at baseline but they have not been used in any publications. In 2014, a series of focus groups to explore the influences on diet were held among 92 participants aged 74-84 years whose diets had already been assessed twice; once in 1998-2001 and once in 2011 [23].

4.3 Estimation of nutrient intake

Following the general procedure outlined in section 2.2, standard portion sizes were allocated to each food in the FFQ based on previously published references [24]. Nutrient intakes were calculated by multiplying the frequency of consumption of a portion of each food by its nutrient content based on the UK national food composition databases (McCance and Widdowson) [25] or manufacturers' composition data where appropriate. Nutrient intakes from dietary supplements were calculated using the frequency and dose reported by the participant, and manufacturers' supplement composition data.

4.4 Response

Table 4.1 Response to dietary measures in HCS

Year	Age (y)	N interviewed	Response to diet question n(%)
1998-2002	59-73	3,225	3,217 (99%)
2011	71-80	592*	442 (75%)

* Invited to interview.

4.5 Key findings

Infant diets

Participants of the HCS born between 1931 and 1939 unsurprisingly had different infant feeding patterns compared to what can be seen today. For instance, over half of the participants were breastfed and there was no association between socioeconomic position (SEP) at birth and type of infant feeding [18, 26]. This is useful because unlike associations from later generations, relationships between infant feeding and health outcomes are unlikely to be confounded by SEP. Breastfeeding in this cohort was associated with greater adherence to a prudent dietary pattern with authors of this study suggesting that early feeding may be linked to later food choice [10, 18].

Adult dietary patterns

Dietary data from the baseline FFQ have been used to identify dietary patterns (DP) using principal component analysis (PCA). Two main dietary patterns were identified using data from the HCS participants at baseline: 1) a diet characterised by high consumption of fruit, vegetables, oily fish and wholemeal cereals termed a “prudent” dietary pattern and 2) a diet characterised by high consumption of vegetables, processed and red meat, fish and puddings called a “traditional” dietary pattern [27]. The FFQ data in HCS have also been used to develop a shorter 24-item FFQ that has the ability to define the prudent dietary pattern in a comparable way to the full FFQ [22]. This tool has the potential to benefit future studies that are interested in capturing information on diet quality of older participants but do not have the capacity to complete a long FFQ.

5 MRC National Survey for Health and Development (NSHD, 1946 British birth cohort)

5.1 Summary of cohort

The Medical Research Council (MRC) National Survey for Health and Development (NSHD), or the 1946 British birth cohort, is the oldest and longest running British birth cohort study [28-31]. NSHD originated from an initial maternity survey of 13,687 births recorded in England, Scotland and Wales during one week in March in 1946, a time when post-war rationing was still underway. Of these births, a socially stratified sample of 5,362 singleton babies born to married parents were selected for follow-up [32]. Participants have been followed up 24 times with the most recent being a postal questionnaire at 68 years and a home visit at 69 years [31]. The initial aim of NSHD was to examine how environmental factors both at home and in school affected physical and mental development and educational attainment. As the cohort has aged interest in how childhood health, development and lifelong social circumstances affect adult health and function grew and the cohort has developed into a life course study of ageing [32].

Overall participation in this study has remained high [31]. Of the 2,546 (47%) original study members who did not participate in the data collection at 68-69 years, 18% had already died, 12% had withdrawn permanently, 11% lived abroad and 7% remained untraceable for more than 5 years. The majority of participants in NSHD are of white ethnic origin. Participants who previously reported poor general health were less likely to participate in the 68-69 year survey [31]. Lower educational attainment, lower childhood cognition, lifelong smoking, not being married and not owning one's own home at 53 years were associated with lower response rates at 60-64 years [29].

5.2 Dietary data collection

Information about dietary intake was collected at ages 4 (1950), 36 (1982), 43 (1989), 53 (1999), 60-64 (2006-2011) and 68-69 years (2014-2015). A summary of the different diet-

related questions asked at each time point is provided in Table 5.1 and in the paragraphs below.

Diet in childhood

In 1950, diet was assessed during the home visit using a 24-hour recall. The mother or carer of the child was asked "*What did this child have for each meal yesterday*" with specific reference to breakfast, dinner, tea or high tea, and last thing at night. The quantity of food consumed was not recorded. There was a further question "*Do you give this child food between meals*" with a yes or no response [33]. It is likely that recorded energy intake may be lower than total energy intake if the child had taken their personal ration of 5oz of sweets per week [33]. The majority of the visits took place in summer (94%) and on a weekday (96%). Therefore, seasonally available fruit and vegetables, e.g. strawberries and lettuces, were probably consumed in greater quantity. Further details about how diet was assessed in 1950, including detailed information about rationing at that time, is outlined by Prynne et al. [33, 34].

Diet in adulthood

Between 1982 and 2006-2011, dietary intake was recorded using 5-day prospective estimated food diaries. In 1982 and 1989 the research nurse gave the participants detailed instructions on how to fill out the food diary and completed an additional 48-hour recall with them. The participant then completed the remaining 5 days of the food diary and returned it by post. If the participant did not send the diary back by post in 1982, the 48-hour recalls were lost. Therefore in 1989, a copy of the 48-hour recall was left with the nurse. In 1999 and 2006-2011, only the 5-day food diary was completed by the participants.

In these food diaries, all food and drink (including alcohol) consumed both at home and away was recorded using household measures to estimate portion sizes. There were

detailed guidance notes of how to describe foods and, from 1989 onwards, photographs of portion sizes provided at the beginning of the diary to assist the participant. In the diaries there were seven spaces for each day to record meals and between-meal snacks, and a reminder section about any other snacks and space in which to write recipes. The food diary in 2006-2011 was slightly different in that it had space to record the specific time the food or drink item was consumed.

There was no food diary collected in 2014-2015, but there were a number of diet-related questions asked during the postal questionnaire (Table 5.1).

Table 5.1 Diet-related questions in NSHD

	1950 Age 4y	1982 Age 36y	1989 Age 43y	1999 Age 53y	2006-2011 Age 60-64y	2014-2015 Age 68-69y
24-hour recall	✓					
48-hour recall		✓	✓			
5-day estimated food diary		✓	✓	✓	✓	
Are you on a special diet?		✓	✓	✓	✓	✓
How many days a week do you usually eat breakfast?						✓
What kind(s) of milk do you usually have at home either in drinks or on cereal? Do not drink/use milk?*						✓
What type(s) of bread do you usually eat? †						✓
How often do you eat fruit and on days you eat, how many portions‡						✓
How often do you eat vegetables not including potatoes and on days you eat, how many portions? ‡						✓

Register at Skylark to view the questionnaires.

Response options:
* Do no drink/use milk, whole milk, semi-skimmed, skimmed, other (specify)
† White, brown, granary, wholemeal, don't often eat bread, other (specify)
‡ Rarely or never, sometimes or not every day, every day or most days.

5.3 Estimation of nutrient intake

Nutrients from the food diaries were estimated following the approach outlined in section 2.2. The coding of the NSHD dietary diary data has advanced over the years through the development by MRC Human Nutrition Research in Cambridge of two in-house programmes: Diet In Data Out (DIDO) and Diet in Nutrients Out (DINO) [35, 36]. In 1982, the dietary data were originally manually coded in Bristol [37]. DIDO was developed to code the 1989 diary data and was also used to code the 1950 24-hour recall and to convert the previously coded 1982 dietary dairy data and the 1999 diet diary data.

DIDO is a specially developed data entry system written in the C programming language [35]. It is designed around a hierarchical food menu consisting of nearly 2000 food and drink items arranged by major food groups and sub-groups as listed in food composition tables. It generates a food code and associated weight in grams for each item recorded. The food codes are taken from the British food composition tables and the portion weights can be chosen from a list of standard weights attached to descriptions appropriate for each food e.g. teaspoon, tablespoon, medium slice etc, These portion weights vary according to the type of food and can be informed by manufacturers information. Once each diary is coded using DIDO, it is linked to British food composition tables [38-41] using a separate in-house suite of programmes to estimate nutrient intakes. Since the nutrient composition of food items were likely to have changed over time, time-appropriate food composition tables were used to estimate the nutrient intake for each diary as outlined previously [42]. For the 2006-2011 dietary data coding, DIDO was updated to a Microsoft Access based system, DINO [36]. DINO includes >6000 food items with their estimated portion sizes and is directly linked with food composition tables to estimate nutrient intakes [36]. The previous diet diaries have now been transferred to DINO; however, there is some minor discrepancy in how the foods were categorised between the years. Vitamin and mineral supplements were coded separately. There were some specific elements of the 1950 24-hour recall that required special attention when coding and these are outlined in detail by Prynne *et al.* [33, 34].

It is not possible to estimate nutrient composition from the 2014-2015 diet-related questions due to insufficient detail captured.

5.4 Response

The majority of participants who responded to the diet diaries at each age (Table 5.2) completed the full 5 days (83-99%). Up to 1999, the majority of diet diaries were completed in summer and autumn (68-94%) and excluding winter (<5%) when shortages of fresh fruit and vegetables would have been most apparent. In 2006-2011, diet diaries were completed equally throughout all four seasons (20-28%).

Table 5.2 Response to dietary measures in NSHD

The original NSHD cohort consisted of 5,362 participants.

Year	Age (y)	N interviewed	Response to diet question n(%)	≥3 days† ‡
1950	4	4,711	4,599 (98%)	N/A
1982	36	3,322	2,428 (73%)*	2,411
1989	43	3,262	2,280 (70%)*	2,256
1999	53	3,035	1,776 (59%)*	1,772
2006-2011	60-64	2,662	1,893 (71%)*	1,869
2014-2015	68-69	2,367‡	2,400	N/A

* N restricted to 5-day diet diaries only
† In 1950 and 2014-2015, no food diaries were collected.
‡ N from postal questionnaire

5.5 Key findings

Children's diets

The participants of NSHD lived through a time of post-war austerity in their early years which directly affected their dietary intake. By 1950, the number of foods available was still in short supply. More information about rationing during this period in relation to NSHD has been discussed by Prynne *et al.* [33, 34]. Three studies examined the diet of NSHD participants in 1950 [33, 34, 43]. In comparison to children in the 1990s, children in 1950 ate a more homogenous diet which contained more bread and vegetables but less sugar and soft drinks [33]. Their diets were higher in fibre and vitamin K but also higher in fat compared to children in the 1990s [33, 43]. Food sources of major nutrients were also different. For example, in 1950, iron came from red meat, but in 1992 it mainly came from fortified breakfast cereals [33]. Rationing was designed to reduce inequalities in food intake, but despite this, there was some evidence of small social and regional differences remaining [34]. Consumption of fruit and vegetables, which were not rationed, was higher among children whose father was classified as being in a non-manual occupational social class compared with manual social class. Some rationed foods (bacon, orange juice and tea) were also associated with social class, but meat and spreading fats were not. Children in Scotland tended to have a lower energy intake and vitamin K than other regions and retained traditional Scottish diets such as porridge and soups [34, 43].

Dietary trends and dietary patterns in adulthood

At 36 years, higher educational attainment was associated with better dietary habits, but in women, this was also associated with higher intakes of fat and alcohol [37]. Disadvantaged social class and low educational attainment were associated with the worst dietary habits [37].

In the 17 year period between 36 and 53 years, there were changes in key nutrient intakes [44]. For example, fat, sodium and iron intakes have fallen while calcium, carotene, folic

acid, vitamin C and fibre intakes have increased [44, 45]. Total haem and non-haem iron rose from 36 until 43 years then decreased at 53 years [46]. There was a decline in haem iron from beef with an increase in that from poultry, possibly reflecting the bovine spongiform encephalopathy (BSE) outbreak from 1990 [46, 47]. Similarly, over a 30 year period between 36 and 60-64 years, white bread was replaced by granary and wholemeal bread, while there was a reduction in the consumption of red and processed meats and an increase in the consumption of vegetables [42]. These changes could be due to ageing, cohort effects or a response to government dietary recommendations and greater availability of foods such as wholegrain bread in the UK.

Five distinct dietary patterns (DPs) were identified using factor analysis on the 48-hour recall at 43 years: “health aware”, “dinner party”, “traditional”, “refined”, “sandwich” [48]. Social class in childhood was associated with the DPs at 43 years, however, social mobility also had an impact. For example, participants who made the transition from manual to non-manual social class partly adopted the “health aware” and “dinner party” DPs of the non-manual SEP [48]. Change in other DPs between 43 and 53 years were also observed [49]. Three DPs among women (“fruit, vegetable and dairy”; “ethnic foods and alcohol”; “meat, potatoes and sweet foods”) and two in men (‘”ethnic foods and alcohol”; “mixed”) were identified from factor analysis of 126 food groups at 43 and 53 years [49]. There was an increase in adherence to the DPs over time with only the “meat, potatoes and sweet foods” DP in women showing a decline.

The dietary diary data at 43 years was used to develop an index to discriminate healthy and unhealthy foods; the Eating Choice Index (ECI) [50]. The index consists of information about breakfast and fruit consumption and type of bread and milk. Higher scores on the ECI are positively associated with protein, carbohydrate, fibre, vitamin C, iron, calcium and folate and negatively associated with fat. Participants with a lower ECI were also more likely to be in a lower social class, obese and less active [50].

Chrononutrition

Since diet diaries were used to collect the dietary data, NSHD provides a unique opportunity to examine a new discipline termed "chrononutrition" which investigates the timing and regularity of food intake [51-55]. Results from these studies have found that the proportion of energy and macronutrients consumed at lunch declined between 36 and 53 years, with greater intakes occurring in mid-afternoon [53]. There was an association between increasing carbohydrate intake in the morning while simultaneously reducing fat intake at 43 years with metabolic syndrome [51] and diabetes [52] at 53 years. Irregular energy intakes at and between meals decreased with increasing age between 36 and 53 years [55]. There was a cross-sectional and longitudinal association between meal irregularity and cardio-metabolic risk [54, 55].

6 National Child Development Study (NCDS, 1958 British birth cohort)

6.1 Summary of cohort

The National Child Development Study (NCDS), also known as the 1958 British birth cohort study, is an on-going, multidisciplinary study. NCDS is the second oldest nationwide birth cohort after the 1946 British birth cohort study (National Survey of Health and Development, NSHD). The aim of NCDS is to monitor social, behavioural, educational and physical outcomes as well as to collect information regarding economic circumstances, employment and health behaviour [56]. The NCDS began as the Perinatal Mortality Study to investigate still-birth and infant mortality. Mothers of babies born in one week in March 1958 in England, Scotland and Wales (approximately 17,415) were interviewed by midwives, who completed questionnaires with reference to medical records [57]. During the childhood sweeps, immigrants that were born during the survey week in March 1958 were added to the study (*n*=~800) [58]. To date, the cohort has been followed up ten times; at ages 7, 11, 16, 23, 33, 42, 46, 50, and 55 years including a biomedical survey at 45 years.

As with all cohort studies, sample attrition has occurred in NCDS. For example, those with a lower socioeconomic position (SEP) at birth, lower mathematics score and with internalising and externalising behaviours at 7 years were found to be under-represented in the 45 year survey [59]. Although immigrants were included during the childhood studies, the majority of participants of the NCDS are from a white European population [59]. Participants of the 45 year biomedical survey were shown to broadly represent those born in Britain in 1958 and resemble the white British population [59].

6.2 Dietary data collection

Information about dietary intake was collected at ages 33 (1991) and 42 (2000), as well as at the biomedical sweep at 45 years (2003). While no established DAT was used, the frequency of consumption of a limited number of specific foods was recorded and these foods varied across sweeps (Table 6.1).

It is noteworthy that in 1991 the questions for fresh fruit and salad or raw vegetables were season-specific, but in 2000 they were not. Participants were also asked if they followed a special diet.

Table 6.1 Diet-related questions in NCDS

	1991 Age 33 y	2000 Age 42 y	2003 Age 45 y
Fresh fruit in summer	✓		
Fresh fruit		✓	
Salads or raw vegetables in winter	✓		
Salads or raw vegetables		✓	
Cooked vegetables		✓	
Eggs		✓	
Chips	✓	✓	
Sweets or chocolates	✓	✓	
Biscuits	✓		
Biscuits and cakes		✓	
Fried food not counting chips	✓		
Food fried in vegetable oil such as sunflower oil, not counting chips		✓	
Food fried in hard fat such as lard or butter, not counting chips		✓	
Type of bread usually eaten*	✓		
Wholemeal bread or rolls		✓	
Other bread or rolls		✓	
Red meat like beef, lamb or pork			
Poultry like chicken or turkey		✓	
Fish		✓	

White fish (e.g. cold, plaice, halibut)			✓
Other fish (e.g. salmon, trout, mackerel, sardines, fresh tuna)			✓
Canned tuna fish			✓
Pulses such as baked beans and lentils		✓	
Tea			✓
Coffee			✓
Milk alone or in milky drinks e.g. hot chocolate			✓
Milk on cereal			✓
Milk-based savoury dishes (e.g. quiche, cheese or white sauce)			✓
Milk-based desserts (e.g. custard, ice-cream, rice pudding)			✓
Hard cheeses			✓
Sort cheeses			✓
Margarine on bread or equivalent			✓
Butter on bread or equivalents			✓
Type of milk usually consumed[†]			✓
On a special diet?		✓	

Click on headings above for links to questionnaire. Age 45y requires special licence to access.

Response options:
In 1991 there were six possible responses: more than once a day, once a day, 3-6 days per week, 1-2 days per week, less than one day per week, never.
In 2000, there were seven possible responses: more than once a day, once a day, 3-6 days a week, 1-2 days a week, less than one day per week, occasionally, never.

In 2003 there were eight possible responses: more than four times a day, 2-4 times a day, once a day, 3-6 days a week, 1-2 days a week, less than one day per week, occasionally, never.

* White bread, wholemeal bread, other brown bread, crispbreads, white pitta bread, wholemeal pitta bread, nan/chapattis, other bread, no bread.
† Whole, semi-skimmed, skimmed, soya, goats, sheep, other, and none.

6.3 Response

Table 6.2 Response to dietary measures in NCDS

Original cohort consisted of 17415 participants.

Year	Age (y)	N interviewed	Response to diet question* n (%)
1991	33	11,469	11,372 (99%)
2000	42	11,419	11,373 (99%)
2003	45	9,377	9,181 (98%)

* Response based on answering at least one of the questions from the dietary questions listed above

6.4 Key findings

Dietary trends and dietary patterns in adulthood

Two studies examined trends in food consumption over this 9 year period between 1991 (33 years) and 2000 (42 years) [60, 61]. For both men and women, dietary habits were slow to change [60, 61]. At 33 years, there was evidence that higher educational attainment was associated with consuming fruit, salad or raw vegetables more frequently and chips and fried food less frequently compared with lower attainment[60]. Parsons *et al.* created a dietary quality score using these data [61]. Briefly, the authors treated fruit and salad as 'healthy' foods with consumption frequencies classified from 1 (least frequent) to 5 (most frequent). Chips, sweets, biscuits and fried food were classified as 'unhealthy' foods with consumption coded in reverse from 5 (least frequent) to 1 (most frequent) so that a higher value indicates better diet quality. As assessed by this measure, overall improvement in diet quality between 33 and 42 years was found to be very small [61].

One study compared dietary intake between NCDS and the 1970 British birth cohort which will be discussed in section 7.5.

7 1970 British Cohort Study (BCS70)

7.1 Summary of cohort

The 1970 British Cohort Study (BCS70) is the third birth cohort study established in Britain. The BCS70 began as the British Births Survey, designed to examine the causes of neonatal morbidity and compare results with those of NSHD [62]. The target sample included just over 17,000 babies born in England, Scotland, Wales and Northern Ireland in one week in April 1970 [63]. Since the initial birth survey there have been nine further major data collections: 1975 (5 years), 1980 (10 years), 1986 (16 years), 1996 (26 years), 1999-2000 (29-30 years), and 2016 (46 years). Data collection on sub-samples has also been conducted at 22 and 42 months and 21 years [62-64]. Cohort members who were born in Northern Ireland were included in the birth survey but dropped from later sweeps. The sample was augmented to include immigrants who were born in the same week in April 1970 at ages 5 (n=68), 10 (n=270), 16 (n=57) and 26 years (n=8). It is worth noting that in 1986, there were postal strikes and industrial action by teachers, and therefore the overall response to this sweep was likely reduced [62, 64]. Information from this study has come from a number of sources (e.g. participants, parents, schools, medical records, doctors) and a variety of instruments (e.g. interview, self-completion, medical records, diaries). Although extensive information has been gathered, the *ad hoc* funding during the 1980s and 1990s made it difficult to develop consistent content and timing for each of the follow-ups [62].

7.2 Dietary data collection

Information about dietary intake was collected during the birth survey and at ages 10 (1980), 16 (1986), 30 (2000), 42 (2012) and 46 (2016) years using different methods. A

summary of the different diet-related questions asked at each time point are outlined in Table 7.1 and in the paragraphs below.

Infant diet

During the birth survey, the carer was asked questions relating to breast feeding and alternatives (Access the questionnaire).

Diet in childhood

Fifteen separate survey documents were used to capture information from participants when they were 10 years old. In the pupil questionnaire form, participants were asked about the frequency of consumption of certain foods and questions relating to purchasing of snacks, bringing snacks to school, and whether the participant received free school meals were also asked (Table 7.1).

The sweep at 16 years, known as 'Youthscan', consisted of 19 separate survey documents. Diet-related questions were asked during the Student Test Booklet/Student Score Form (Documents B & C, section titled 'What I Eat' and 'Soft Drink Special'), Health-Related Behaviour Student Self-Completion (Document F), 'Home and All That' Student Self-Completion (Document G), Maternal Self-competition Form (Document P). In the Maternal Self-Completion Form, the participant's carer was asked an extensive amount of diet related questions about the teenager as well as cooking and preparation habits. These questions have not been outlined in detail in Table 7.1 as there is overlap with the self-completion dietary questions, but can be found on the relevant questionnaire.

In addition to the self-completed dietary habits, the teenagers were asked to keep a 4 day estimated diet diary. The diaries were distributed through schools or sent by post to the participant's home where appropriate. Participants were provided with instructions both within the diary and as an accompanying letter. Examples were provided throughout the

diary. Participants were instructed to complete the diary on a Friday, Saturday, Sunday and Monday of one week. They were asked to include information about the type, brand, amount and time of all food eaten along with additional information about their eating habits. The diary had separate sections for before breakfast, breakfast, mid-morning between breakfast and midday meal, midday meal, mid-afternoon between midday meal and evening meal, evening meal and evening snacks. it was noted that many participants were revising for exams at home or were on holiday from school during the period of recording [65].

Diet in adulthood

At age 30, the frequency of consumption of a limited number of specified foods were recorded. These questions were identical to the questions asked in NCDS when participants were 42 years as a simultaneous survey of both cohorts was conducted in 1999-2000 using the same questionnaire. Participants were also asked if they were a vegetarian and/or on any special diet.

A small number of diet-related questions were asked during the self-completion questionnaire in 2012 when participants were 42 years.

In the latest data collection in 2016-2017 (46 years) dietary intake was collected using an online diet diary. The Oxford WebQ, developed by the Cancer and Epidemiology Unit at the University of Oxford was used [66]. Briefly, participants are asked to report all food and drink consumed prior to the day they completed it along with portion sizes. Participants completed two 24-hour recalls. They were randomly allocated to complete the survey on one weekday and one weekend.

Table 7.1 Diet-related questions in BCS70

	1980 Age 10 y	1986 Age 16 y				1999-2000 Age 29-30 y	2012 Age 42 y	2016 Age 46 y
Questionnaire source	Pupil form	B & C	F	G	Diet-Diary	Questionnaire	Questionnaire	
4-day diet-diary					✓			
Online diet-diary								✓
24-hour recall*			✓					
Frequency of fresh fruit						✓		
Frequency of salad/raw vegetables						✓		
Frequency of cooked vegetables						✓		
Frequency of white bread	✓	✓						
Frequency of brown bread	✓							
Frequency of wholemeal/granary bread		✓						
Frequency of wholemeal bread or rolls						✓		
Frequency of other bread or rolls						✓		
Frequency of breakfast cereal		✓						
Frequency of butter	✓	✓						
Frequency of margarine	✓	✓						
Frequency of cheese	✓	✓						
Frequency of eggs	✓	✓				✓		
Frequency of pulses						✓		
Frequency of meat	✓	✓						

Frequency of red meat					✓
Frequency of chicken or turkey		✓			
Frequency of poultry					✓
Frequency of fish	✓	✓			✓
Frequency of chips		✓			✓
Frequency of food fried in vegetable oil					✓
Frequency of food fried in hard fat					✓
Frequency of chocolate/sweets	✓				✓
Frequency of sweets		✓			
Frequency of chocolate		✓			
Frequency of puddings		✓			
Frequency of biscuits and cakes of all kinds					✓
Frequency of cakes or buns		✓			
Frequency of sweet biscuits		✓			
Frequency of crisps		✓			
Cups/glasses tea	✓				
Frequency of tea		✓			
Cups/glasses cocoa	✓				
Frequency of cocoa		✓			
Cups/glasses coffee	✓				
Frequency of coffee					
Cups/glasses milk	✓				

Frequency of milk		✓				
Cups/glasses cola	✓					
Frequency of cola		✓				
Frequency of low calorie or sugar free drinks		✓				
Frequency of fresh fruit juice		✓				
Frequency of fruit squash		✓				
Cups/glasses water	✓					
Frequency of water		✓				
Type of lunch yesterday[†]			✓			
Type of breakfast yesterday[‡]			✓			
Number of days consuming breakfast						✓
How much milk sugar and sweetener you add to tea or coffee				✓		
Are you a vegetarian/special diet				✓	✓	
Number of times per week you get food from takeaway				✓		
Frequency of takeaways						✓
Frequency of home-cooked meal						✓
Frequency of ready meals						✓
Frequency of other convenience foods						✓

Click on headings for links to questionnaire.

Documents B & C: Student Test Booklet/Student Score Form; Document F: Health-Related Behaviour Student Self-Completion Questionnaire; Document G: 'Home and All That' Student Self-completion Questionnaire.

Response options:
In 1980 responses for frequency questions were: nearly every day, quite often, sometimes, and hardly ever. In 1986 responses for frequency questions ranged from zero to seven times per week. A separate 'soft drinks' section assessed the consumption of drinks with a variety of responses in 1986.
In 2000 responses for frequency questions were: more than one per day, one per day,3-6 days per week,1-2 days per week, less than one day a week, occasionally, never.
In 2003, responses were: one per day, one per day, several times a week, once or twice a week, at least once a month, less often, never.

* Recall asked about specific items including amounts of: meat, fish, eggs/cheese, milk, tea/coffee, cereal, bread, soup, potatoes, baked beans, rice/spaghetti, packets of crisps, ice lollies, ice cream, mousse, sweets, chocolate biscuits of bars, biscuits, cakes or tarts, fruit pies, puddings, squash or cordial, fizzy drinks, fruit juice, fresh fruit, raw vegetables or salads, cooked vegetables (not potatoes), alcoholic drinks, other items.

† Over counter in school/packed lunch in school/outside school takeaway/outside school packed lunch/at home/did not have lunch.

‡ Nothing, just something to drink, cereal or bread and drink, cereal and bread and drink, just an egg and drink, cooked breakfast with bread and drink, cooked breakfast with cereal and bread and drink.

7.3 Estimation of nutrient intake

Nutrient intakes from the 16 year dietary data were estimated as outlined by Crawley *et al.* [65]. It is notable that the procedures used to code this data were not supported by specially developed software as in section 5.3. Briefly, coding was completed using standard food portion sizes [67] from a list of 1250 foods. McCance and Widdowson's The composition of Foods 4th Edition was used as the nutrient database [38] along with additional information on the nutrient contents of other products as outlined by Crawley *et al.* [65]. There was no evidence of differences between weekday and weekend nutrient intakes and it was noted that many participants were revising for exams at home or were on holiday from school during the period of recording [65].

Nutrients from the 46 year online diet diary were estimated automatically within the Oxford WebQ, [66] from McCance and Widdowson's The Composition of Foods and its supplement reports [25, 39-41, 66, 68-72].

7.4 Response

Table 7.2 Response to dietary measures in BCS70

Original cohort consisted of 18,640 participants (including those not born in Great Britain, added during school years).

Year	Age (y)	N interviewed	Response to at least one diet question n(%)
1970	Birth	17,196	17,175 (99.9%)
1980	10	14,869	12,695 (85%)
1986	16	11,615	6,651*
2000	30	11,261	11,205 (99.5%)
2012	42	9,841	8,721 (88.6%)
2016	46	8,581	5,950 (69.3%)

* Participant response, carer questionnaire n=8,993. n=4760 competed the 4 day unweighted diet diary.

7.5 Key findings

Diets of teenagers

The majority of diet-related analyses in BCS70 were cross-sectional and conducted in the 1990s using the 16 year diet diaries [65, 73-79]. Teenager's intakes of fats and extrinsic sugars exceed the 1991 Department of Health recommendations and intakes of milk sugars, starch and non-starch polysaccharides were lower than recommended [65]. Regular breakfast consumption at 16 years was associated with lower intakes of fat while non-consumers had lower micronutrient intakes [79]. Higher fibre breakfast cereals were more likely to be consumed in London and the Southeast than in Scotland and the North

and less likely to be consumed as the socioeconomic position declined [79]. When looking at regional differences, dietary intake of Scottish teenagers was different compared to the rest of Great Britain even after accounting for smoking, alcohol, family size and family tenure [73]. These teenagers had lower intakes of fibre, some micronutrients, non-processed vegetables, and polyunsaturated fat spread and higher intakes of soft drinks, chips and white bread [73]. Two studies examining the dietary intakes of dieting teenagers found that their total energy and micronutrient intake were lower than non-dieters but their protein intake as a percentage of energy was higher [74, 75]. Teenagers whose parents smoked had diets that were lower in fibre, vitamin C, folate and magnesium with lower intakes of fruit juices, wholemeal bread and vegetables compared to those with non-smoking parents [77]. In a similar study among teenage smokers, the authors found they consumed less fibre and vitamin C, as well as fewer puddings, biscuits, wholemeal bread, fruit juices [78]. Eating takeaway meals twice or more per week, consuming two or more soft drinks per day and a history of dieting to lose weight at 16 years was associated with an increase in BMI z-scores between 16 and 30 years [80].

Comparison of diet between NCDS and 1970 British birth cohort

In a study that compared dietary intake between NCDS and the 1970 British birth cohort, the authors identified and compared clusters of health behaviours, including diet, smoking, alcohol and physical activity among participants in their thirties. The authors used principal component analyses to summarise dietary intake into three variables; fruit and vegetable, chips and fried food, sweets, chocolate and biscuits. They identified three clusters that were similar among men and women: a risky group, a moderate smokers group and a mainstream group. The mainstream group included not smoking, frequent fruit and vegetable consumption, less frequent consumption of chips and fried food and being more physically active [81]. Consumption of sweet foods, however, was also common in the mainstream cluster. Cluster patterns were similar between men and women and across cohorts. More people in the BCS70 fell into the mainstream group and tended to have healthier behaviours (except alcohol) than NCDS.

8 Understanding Society (UKHLS)

8.1 Summary of study

Understanding Society, also known as The UK Household Longitudinal study (UKHLS), is a panel study of approximately 40,000 households in the UK which began in 2009 [82]. All members of the household aged 16 years and over complete a survey on a yearly basis. Interviews are via an online questionnaire or by a face-to-face or telephone interview. Each wave takes place over a 24-month period [82]. Members of the household who are aged 10-15 years are asked to complete a short self-completion youth questionnaire until they reach 16 years. UKHLS has a complex sample design which has been outlined in detail in a previous report [83]. Briefly, the overall survey consists of: a general population sample, members of the British Household Panel Survey (which ran from 1991/92 to 2008/09 (from Wave 2)), and an immigrant and ethnic minority boost sample from Wave 6 onwards.

The overall aim of UKHLS is to provide longitudinal data to describe the health, work, and education, economic, social and family life of the UK population and provide a platform to understand social and economic change and policy interventions.

8.2 Dietary data collection

While there were no FFQs or diet diaries collected, there are a number of diet-related questions (Table 8.1). From Wave 7, some of these questions were based on the Eating Choice Index which has been shown in NSHD to discriminate unhealthy and healthy eating [50].

In addition to the questions in Table 8.1, mothers answered information about their child's breastfeeding including age when breastfeed was stopped.

Table 8.1 Diet-related questions in UKHLS

Question	Index term	Datafile*	1991-2008 BHPS[†]	2009-11 W1	2010-12 W2	2011-13 W3	2012-04 W4	2013-15 W5	2014-16 W6	2015-17 W7	2016-18 W8	2017-19 W9	2018-20 W10	2019-21 W11
Data deposit				2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Eat meat, chicken, fish every second day (yes/no) [‡]	hscane	hhresp	✓											
Does the child eat fruit and/or vegetables every day (yes/no) [‡]	cdepdo5	hhresp					✓		✓		✓			
Frequency of eating out[§]	lacte	indresp	✓											
Frequency of fruit (frozen, dried and fresh) [‖]	wkfruit	indresp			✓			✓		✓		✓		
Frequency of vegetables (tinned, frozen, dried and fresh, not potatoes) [‖]	wkvege	indresp			✓			✓		✓		✓		
On days you eat it, number of portions of fresh fruit and vegetables per day	fruvege	indresp			✓			✓						
On days you eat it, number of portions of fruit	fruitamt	indresp								✓		✓		

On days you eat it, number of portions of vegetables	vegeamt	indresp				✓	✓
Type of milk used[¶]	usdairy	indresp	✓	✓	✓	✓	
Type of bread used[**]	usbread	indresp	✓	✓	✓	✓	
Number of days breakfast consumed	breakfst	indresp			✓	✓	
Eats food from where born[††]	food1	indresp	✓	✓		✓	
Eats food from mother's country of birth[††]	food2	indresp	✓	✓		✓	
Eats food from father's country of birth[††]	food3	indresp	✓	✓		✓	
Eats food from maternal grandmother's country of birth[††]	food4	indresp	✓	✓		✓	
Eats food from maternal grandfather's country of birth[††]	food5	indresp	✓	✓		✓	
eats food from paternal grandmother's country of birth[††]	food6	indresp	✓	✓		✓	

eats food from paternal grandfather's country of birth[††]	food7	indresp			✓		✓			✓		
Frequency of fresh fruit or vegetables[‡‡]	ypfrut	youth	✓									
number of portions of fresh fruit and vegetables per day[§§]	ypfrutppd	youth		✓	✓		✓		✓	✓	✓	
Frequency of fast food[‡‡]	ypffd	youth	✓									
Frequency of breakfast[‡‡]	ypffdwk	youth		✓		✓		✓		✓	✓	
Frequency of crisps, sweets or fizzy drinks[‡‡]	ypjfd	youth	✓	✓		✓		✓		✓	✓	

* hhresp: house-hold level; indresp: individual level; All index terms are searchable on the Understanding Society website.
† Not all waves of BHPS asked these questions; see the Understanding Society questionnaires for details.
‡ These questions were designed to assess derivation rather than diet.

Response options:
§ At least once a week/at least once a month/several times a year/once a year or less/never or almost never
| Never/1-3 days/4-6 days/every day
¶ Whole/semi-skimmed/skimmed/soya/any other/ don't use milk.
** White/wholemeal/Granary or wholegrain/both brown and white/don't eat bread /other type of bread.
†† Every day/3-6 days a week/ 1-2 days a week/a least monthly/at least every 6 months/rarely or never/special occasion.
‡‡ Every day or nearly/about once a week/every now and then/ never or hardly ever.
§§ 5 or more/3-4 portions/1-2 portions/none.

8.3 Response

Table 8.2 Response to dietary measures in UKHLS: Individual questionnaire

Wave	N*	Response† n(%)
2	50,688	50,668 (99.9%)
5	40,975	40,952 (99.9%)
7	39,337	39,283 (99.9%)
8‡	8,075	7,878 (97.6%)
9	34,959	34,901 (99.8%)

*N= number of full interviews.
† Non-response = missing, don't know, refusal responses; all figures are unweighted.
‡ ethnic minority boots only

Table 8.3 Response to dietary measures in UKHLS: Youth questionnaire

Wave	N*	Response† n(%)
1	4,899	4,873 (99.5%)
2	5,018	4,955 (98.7%)
3	4,427	4,400 (99.4%)
4	4,045	3,971 (98.2%)
5	3,655	3,528 (96.5%)
6	3,459	3,422 (98.9%)
7	3,629	3,590 (98.9%)
8	3,272	3,221 (98.4%)
9	2,821	2,801 (99.3%)

* N= number of full interviews.
† Non-response = missing, don't know, refusal responses; all figures are unweighted.

8.4 Key findings

The dietary data in UKHLS have not been used extensively.

The relationship between fruit and vegetable consumption and well-being

A paper using dietary data and mental wellbeing scores provides further evidence that persuading people to consume more fruits and vegetables may not only benefit their physical health in the long-run, but also their mental well-being in the short-run [84].

Consumption of ethnic food

An Institute for Social and Economic Research (ISER) working paper from 2014 found that the maintenance of an ethnic origin diet was associated with healthier eating patterns [85].

Diets of young people

Out of two papers examining diet in the youth sample, one found that the majority of them did not eat at least five portions of fruit and vegetables per day and being a boy in lower income households and of Pakistani and Bangladeshi ethnicity (compared with white ethnicity) were associated with lower odds of meeting dietary recommendations [86]. Higher fruit and vegetable intakes was associated with higher odds of happiness and lower odds of socio-emotional difficulties and consumption of fast food [87].

9 The Avon Longitudinal Study of Parents and Children (ALSPAC)

9.1 Summary of cohort

The Avon Longitudinal Study of Parents and Children (ALSPAC), also known as Children of the 90s, is an ongoing birth cohort study of a sample of the population from Bristol and the surrounding area [88]. The main aim of ALSPAC is to understand how genetic and environmental factors influence the health and development of parents and children.

During initial recruitment all pregnant women who were resident in the former county of Avon, an area around Bristol in South West England, with an expected delivery date between 1st April 1991 and 31st December 1992 were invited to participate [88, 89]. ALSPAC initially enrolled a cohort of 14,541 pregnancies. When the oldest children were approximately 7 years old, additional eligible participants were invited to join the study. Therefore, the total sample for the child-based data collected at 7 years is 15,589 with 14,901 alive at 1 year of age. All of these children have been regularly followed up using parental and self-completion questionnaires, medical records, educational and clinical assessment and through linkage. A proportion of children born in the last 6 months of the recruitment phase (equivalent to 10% of the whole cohort) was selected to take part in a sub-study known as 'Children in Focus' (CiF). These children attended clinics between 4 months and 5 years of age (n=1432 ever attended).

In addition to studies of the children, ALSPAC has also followed up the mothers ('Focus on the Mothers'), fathers ('Focus on the Fathers') and the children of the Children of the 90s.

Compared with the whole of Great Britain in 1991, the population of mothers with infants under one year of age resident in Avon were more likely to live in owner occupied accommodation, to have a car and less likely to have one or more persons per room and be non-white [90] . Similarly when comparing the ALSPAC participants to the whole eligible Avon population, less affluent people and ethnic minorities were less likely to be

represented [90]. Ethical approval for the study was obtained from the ALSPAC Ethics and Law Committee and the Local Research Ethics Committees.

9.2 Dietary data collection

ALSPAC collected dietary information from both mothers, their partners and children at various time points (Table 9.1) using FFQs and diet diaries. The study website contains details of all the data that are available through a fully searchable data dictionary and variable search tool. Since a number of FFQs were conducted we provide links to relevant questionnaire sources in Table 9.2. Details of the dietary collection methods have been discussed in a previous publication and will be briefly outlined here [91].

Table 9.1 Diet-related questions in ALSPAC

	Mother's FFQ	Partner's FFQ	Child's FFQ	Child's diet diary[‡]
32 weeks gestation (1991/1992)	✓	✓ (Partial)		
4 weeks (1991/1992)			✓ Infant feeding	
4 months (1992/1993)				✓*
6 months (1991/1993)			✓ [†]	
8 months (1992/1993)				✓*
15 months (1992/1994)			✓ [†]	
18 months (1994)				✓*
2 years (1994/1995)			✓	
3 years (1995/1996)			✓	
3½ years (1996)				✓*
4 years (1996/1997)	✓	✓	✓	
5 years (1997)				✓*
6/7 years (1997/99)			✓	

7 years (1998/2000)				✓
8/9 years (2000/02)	✓	✓	✓	
10 years (2002/2003)				✓
12/13 years (2004/2006)	✓	✓	✓ (part parent, part child)	
13 years (2004/2006)				✓

* CIF – 10% subsample.
† Infant FFQ not detailed enough to estimate energy intake.
‡ one day diet diary at 4 months. 3 day diet diary for other years .

Table 9.2 Questionnaire sources for FFQs

Child's Age	Questionnaire source	File	Link to questionnaire
32 weeks gestation	Carer questionnaire	C	http://www.bristol.ac.uk/media-library/sites/alspac/migrated/documents/ques-m04-your-pregnancy.pdf
4 years	Carer questionnaire	J	http://www.bristol.ac.uk/media-library/sites/alspac/migrated/documents/ques-m09-mothers-new-questionnaire.pdf
9 years	Carer questionnaire	N	http://www.bristol.ac.uk/media-library/sites/alspac/migrated/documents/ques-m13-mother-and-family.pdf
12 years	Carer questionnaire	S	http://www.bristol.ac.uk/media-library/sites/alspac/migrated/documents/ques-m17-twelve-years-on.pdf
32 weeks gestation	Partner questionnaire	PB	http://www.bristol.ac.uk/media-library/sites/alspac/migrated/documents/ques-p02-partners-questionnaire.pdf
4 years	Partner questionnaire	PG	http://www.bristol.ac.uk/media-library/sites/alspac/migrated/documents/ques-p07-partners-new-questionnaire.pdf
9 years	Partner questionnaire	PL	http://www.bristol.ac.uk/media-library/sites/alspac/migrated/documents/ques-p11-father-and-family.pdf
12 years	Partner questionnaire	PQ	http://www.bristol.ac.uk/media-library/sites/alspac/migrated/documents/ques-p15-partner-about-me.pdf
4 weeks	Child-based questionnaire	KA	http://www.bristol.ac.uk/media-library/sites/alspac/migrated/documents/ques-cb01-my-young-baby-girl.pdf

6 months	Child-based questionnaire	KB	http://www.bristol.ac.uk/media-library/sites/alspac/migrated/documents/ques-cb02-my-daughter.pdf
15 months	Child-based questionnaire	KC	http://www.bristol.ac.uk/media-library/sites/alspac/migrated/documents/ques-cb03-my-infant-daughter.pdf
2 years	Child-based questionnaire	KE	http://www.bristol.ac.uk/media-library/sites/alspac/migrated/documents/ques-cb05-my-little-girl.pdf
3 years	Child-based questionnaire	KG	http://www.bristol.ac.uk/media-library/sites/alspac/migrated/documents/ques-cb07-my3-year-old-boy.pdf
4 years	Child-based questionnaire	KK	http://www.bristol.ac.uk/media-library/sites/alspac/migrated/documents/ques-cb09-my-young-4-year-old-boy.pdf
7 years	Child-based questionnaire	KQ	http://www.bristol.ac.uk/media-library/sites/alspac/migrated/documents/ques-cb14-my-son-at-school.pdf
9 years	Child-based questionnaire	KT	http://www.bristol.ac.uk/media-library/sites/alspac/migrated/documents/ques-cb18-my-daughter-at-home-and-at-school.pdf
12-13 years	Child-based questionnaire	TA	http://www.bristol.ac.uk/media-library/sites/alspac/migrated/documents/ques-cb25-my-teenage-son.pdf
12-13 years	Child-completed questionnaires	CCM	http://www.bristol.ac.uk/media-library/sites/alspac/migrated/documents/ques-c17-food-and-things.pdf

Note: The ALSPAC website contains full details of all the data that are available through a fully searchable data dictionary and variable search tool

Mother's and partners' diets

At 32 weeks gestation, a self-competed FFQ with 43 food groups and 8 basic foods was used to assess diets of the pregnant women [92]. The food list was developed by nutritionists in Bristol in 1990. It aimed to cover all the main foods consumed in Britain based on those used in a study in South Wales [93] and modified according to a study which had recently collected weighed food intake data among adults in Avon [94]. A separate shorter version of the FFQ was sent to the women to pass onto her partner if she chose to do so.

Participants were asked to report the frequency of consumption of these foods with the following possible responses: (i) never or rarely (ii) once in two weeks (iii) 1-3 times a week (iv) 4-7 times a week (v), or more than once a day. Portion sizes were not reported. Further questions about more detailed aspects of the diet were asked such as: amount of fat on meat, type of bread, type of milk, and type of fat used for spreading and cooking. Participants were also asked if they were on a diet and if they were taking supplements.

Similar FFQs were used to assess the diet of mothers and their partners when the child was aged 4, 8 and 12 years. The food list was expanded to include 56 food groups and 12 drink groups based on experience gained when analysing the pregnancy FFQ and informed by foods and drinks recorded in the diet records collected on the 3.5 year olds. Questions about how many alcoholic drinks per day were also asked in more detail.

Children's diets: FFQs

Parents completed information about the child's diet at age 4 weeks, 6, 15 and 24 months as part of postal questionnaires. A range of questions were asked including: length of breastfeeding and/or formula, type of milk consumed, and age at which various solids were introduced. An infant FFQ was used at 6 and 15 months and 24 months. Responses to the infant FFQs included yes/no to if the baby has ever had the food along with the age started and the number of times per week. The questions cover ready-prepared baby

foods, family foods and drinks. These questionnaires are not detailed enough to allow estimation of energy or nutrient intakes.

A full FFQ was completed by the main caregiver on behalf of the children when they were aged 3, 4, 7 and 9 years. This FFQ was adapted from the one used to assess maternal diet at 32 weeks gestation. There were some modifications over time; for example, from the age of 4 separate categories for coated poultry and coated fish were included [95]. From 7 years, separate questions were asked to establish what was eaten during school hours.

At 12/13 years, the child completed a 54-item FFQ which included items specific to school dinners, as well as other foods normally eaten foods outside the home. At the same time, parents completed an 80-item FFQ on behalf of the child covering foods provided by the parents including packed lunches but excluding school dinners and foods consumed outside the home. This FFQ was adapted from the maternal FFQ. These FFQ need to be used together to estimate energy and nutrient intakes and dietary patterns.

Children's diets: Diet diaries

As part of the Children in Focus subsample, diet was assessed at 4, 8, 18 months and 3½ and 5 years using a three-day diet diary (one day diet diary at 4 months). These were not administered at the exact same ages as the FFQs. It was suggested that one weekend and two weekdays should be included in these diet diaries and they did not have to be consecutive days. The parents were asked to record all foods and drinks consumed by the child in household measures and bring the diary to the clinic visit where, if possible, any anomalies in the diary were clarified by a member of the nutrition team. From 3½ years onwards questions about vitamin supplements, types of spread normally used and types of bread and milk used were also asked in a separate short questionnaire accompanying the diary.

At 7 years, parents of the whole cohort were sent a 3-day diet diary to complete about their child. At 10 and 13 years, the diary was designed for the child to complete with the help of their parents.

9.3 Estimation of nutrient intake

Food Frequency Questionnaires

Estimated nutrient intake from the FFQs were calculated by multiplying the weekly frequency of consumption of each food item by the nutrient content (from McCance and Widdowson's 'The Composition of Food's' and it's supplement reports) of a standard portion of that food item [24] and summing for all food/drinks in the questionnaire. Portion sizes were allocated according to the age of the participants. For children, there was no differentiation between boys and girls; however for adults the portions were larger for men than women [91]. Using information from the diet diaries collected when the children were 3½ years, Bristol-based nutritionists refined the proportion of individual foods to use when estimating the nutrient intake of each food group [91]. They also contacted schools to obtain copies of menus and serving sizes [91].

Diet diaries

At each age from 18 months, the diet diaries were coded using DIDO as described in section 5.3 [35]. Where appropriate, portion sizes were based on average portion sizes for children from previously published data [96-98] or based on manufacturers' information or by adapting adult portion sizes [24] .

9.4 Response

Table 9.3 provides the response to each dietary assessment as outlined in a previous publication [91]. The overall cohort consisted of, mothers and partners (n=14 541 pregnancies), children (n=14 062 live births, 13 988 alive at 1 year; clinic visits for whole cohort n=13 602 available at 7 years). The 10% CiF subsample included n=1432 attending at least once.

Table 9.3 Response to dietary measures in ALSPAC

	Mother's FFQ Response n (%)	Partner's FFQ Response n (%)	Child's FFQ Response n (%)	Child's diet diary Response n (%)
32 weeks gestation (1991/1992)	12,423 (85)	9,960 (68)		
4 weeks (1991/1992)			12,353 (88)	
4 months (1992/1993)				964 (67)*
6 months (1991/1993)			11,490 (82)	
8 months (1992/1993)				1,131 (79)*
15 months (1992/1994)			11,077 (79)	
18 months (1994)				1026 (72)*
2 years (1994/1995)			10,432 (75)	
3 years (1995/1996)			10,145 (73)	
3½ years (1996)				863 (60)*
4 years (1996/1997)	9,504 (65)	5,102 (35)	9,722 (70)	
5 years (1997)				772 (54)*
6/7 years (1997/99)			8,512 (61)	
7 years (1998/2000)				7,309 (54)

8/9 years (2000/02)	7,661 (53)	3,638 (25)	7,965 (56)	
10 years (2002/2003)				7,474 (55)
12/13 years (2004/2006)	6,819 (47)	3,340 (23)	6,781 (48) (parent) 6,780 (48) (child)	
13 years (2004/2006)				6,113 (45)

* CIF – 10% subsample.

9.5 Key findings

A number of review papers using the ALSPAC dietary data have previously been published [99-102]. These describe over 100 papers published about diet in ALSPAC covering 4 research areas: pregnancy, infancy, childhood and dietary patterns.

Maternal diet during pregnancy

One of the strengths of ALSPAC is its ability to capture maternal diet during pregnancy. Results from papers analysing maternal diet from FFQs in ALSPAC found that median intakes were above the recommended nutrient intakes for the majority of nutrients but not for iron, magnesium, potassium or folate and that not many women took supplements [92]. Since folate is an important nutrient to prevent neural tube defects, this finding strengthens the argument for fortification of stable foods with folate.

Five dietary patterns (DP) were described in this sample of women using PCA: 1) 'health conscious' characterised by high consumption of salad, fruit, rice, pasta, breakfast cereals, fish, eggs pulses and non-white bread; 2) 'traditional British' characterised by high consumption of all vegetables, meat and poultry; 3) 'processed' high consumption of high-fat processed foods; 4) 'confectionery' high consumption of snack foods and high sugar content; 5) 'vegetarian' high consumption of meat substitutes, pulses, nuts and herbal tea [103]. These DPs were socially patterned e.g. higher consumption of a health conscious DP was associated with higher education and older age [103].

The effects of maternal diet during pregnancy on their children's health was assessed in a number of papers. For example, higher maternal fish consumption during pregnancy was associated with higher verbal IQ at 6 to 8 months as well as higher development scores between 15 and 18 months [104, 105]. These papers concluded that the benefits outweigh the risks of fish consumption during pregnancy (e.g. there was no indication of fish consumption being associated with high total mercury concentrations).

Partner's diet

When the children were 4 years old, the mother's partners' (men only) DPs were similar to the DPs identified during pregnancy: 1) 'health conscious' 2) 'traditional' 3) 'processed/confectionery', and 4) 'semi-vegetarian'" [106]. As with the women, there were strong associations between these DPs and sociodemographic variables [106].

Children's diet

Diet in infancy has been described [99, 107]. DPs of the children at 3, 4, 7 and 9 years have also been described [108-110]. Three main DPs were identified at each of these childhood ages: 1) 'processed/junk food,' 2) 'health conscious', and 3) 'traditional British'. These DPs were socially patterned and while similar patterns were identified at each childhood point, stronger periods of change were apparent between 3 and 4 and 7 and 9 years. DPs in adolescents were also described by combining FFQ information from both the parents and the child: 1) 'traditional/health conscious', 2) 'processed' 3) 'snacks/sugary drink', and 4) 'vegetarian"'. There were clear sociodemographic differences. It was also noted that capturing dietary intake among adolescences is a difficult task and that using sources from both the parents and children themselves increased accuracy [111].

ALSPAC has collected diet longitudinally over the first 13 years of the study child's life and has the ability to assess dietary change. The stability over time was assessed by obtaining dietary patterns using cluster analysis of 3 diet diaries kept for the same children at ages 7,

10, and 13 years[112] . A healthy cluster was identified and was the most stable pattern, with half of the children starting in that cluster remaining in it at all three ages. A processed cluster was the next most stable, with approximately 40% retained. This suggests that children introduced to either of these types of dietary pattern by 7 years of age are likely to continue with this pattern into adolescence.

A strength of the dietary data in ALSPAC children is the fact that they capture school lunches in the context of overall dietary intake which can support public health guidelines. While the nutrient composition of both school dinners and packed lunches were below dietary guidelines, children eating packed lunches had poorer nutrient intakes overall than those eating school dinners [113].

10 Southampton Women's Survey (SWS)

10.1 Summary of cohort

The Southampton Women's Survey (SWS) is a prospective cohort study of mothers and their children. The cohort began as a study of non-pregnant women aged 20-34 years registered with a general practitioner in Southampton between 1998 and 2002 [114]. A total of 12,583 women (75% of all women contacted) were interviewed. A sub-group of women who did not become pregnant were followed-up two years after their initial interview (*n*=94) [115]. Women who became pregnant after the initial interview were invited to take part in the pregnancy phase of the survey at Southampton Princess Anne Hospital at 11, 19 and 34 weeks gestation. By the end of 2007, 3,158 singleton live babies had been born to these women [116]. To date, these babies have been followed up with home visits at 6 months, 1, 2, and 3 years. Due to the study design, the data from the children are collected over a range of years. A sub-sample of children were examined at 4 years, 6-7 years, 8-9 years and 11-13 years.

The initial aim of the study was to examine maternal factors affecting fetal growth. This goal has widened to include the effects on post-natal and early childhood growth. Diet

and body composition have been the main focus of this study with additional information such as physical activity, lifestyle and social circumstances also being collected [114].

10.2 Dietary data collection

The SWS collected dietary information from both women and their children using three methods: FFQ, prospective food diaries and 24-hour recalls. The most commonly used DATs were FFQs. All questionnaires outlining the dietary assessments can be found on the SWS website. Table 10.1 outlines the methods and timing of these DATs.

Women's diets

During the initial home visit and at 11 and 34 weeks' gestation, research nurses assessed dietary intake during the preceding three months using a 100-item FFQ. The foods or food groups included in the FFQ were based on their ability to contribute at least 90% of the macronutrients, iron and vitamin C in the diet based on published data [117].

Women reported their average frequency of consumption of each food group using the following responses: (1) never, (2) once every 2-3 months, (3) once per month, (4) once per fortnight, (5) 1-2 time per week, (6) 3-6 times per week, (7) once a day or (8) more than once per day (with the option to specify the number of times per day). Prompt cards with lists of foods included in food groups were used to ensure standardised responses. The amount of milk and sugar consumed daily over the last three months as well as the average portion size of bread and potatoes were also recorded. The frequencies of consumption of foods not listed on the FFQ were recorded if they were consumed ≥1x/week.

The 100-item FFQ was used during a home visit to record the dietary intake of the sub-group of non-pregnant women two years after the initial interview to assess stability of dietary patterns over time. In addition to the FFQ, participants were asked '*Have there*

been any major changes to your diet since we saw you two years ago?' and if '*yes'*, details of the changes were recorded.

Children's diets: 6 to 12 months

At approximately 6 and 12 months, an FFQ and details of the child's milk-feeding history over the prior 6 months as reported by their main caregiver (usually the mother) were recorded by research nurses. Breast milk intake was estimated from the reported duration of breast-feeding at each feed [118] and the age of introduction to solid foods was recorded.

Two infant FFQs were developed using a variety of dietary information sources. The list of foods to be included was compiled using information from a nationally representative sample of children aged 18 months [97], the weighed food diaries of preterm infants aged 6 and 12 months [119], infant-feeding literature and dietary data from women in Southampton [120]. This food list was refined after a 24-hour recall of a sample of infants and through piloting [121].

At 6 months, a 34-item FFQ was administered to capture average frequency and amount of listed foods consumed over the 7 days preceding the interview. Responses included the number of times the food/food group was consumed over the past week, the brand and amount consumed in household measured.

At 12 months, a 78-item FFQ was administered to capture the listed foods over the month preceding the interview. Responses included: never, 1-3 times per month, 1 to 7 times per week, more than once a day (with the option to specify the amount of times per day).

For both the 6 and 12 month FFQs, prompt cards listing foods included in each food group were used at both ages to ensure standardised responses and portion sizes were recorded in household measures and with the aid of food models. Participants were also asked to report frequencies of consumption and amounts of any foods that were not listed in FFQ if they were consumed once a week or more.

In addition to these FFQs, a 24-hour diet recall was conducted in the whole sample at 6 months and a 4-day weighed food diary was conducted among fifty mothers of 6 month olds, and fifty mothers of 12 month old babies [122, 123].

Children's diets: 3 to 11 years

At 3 years diet was assessed using an 80-item FFQ administered by research nurses to the main caregiver (usually the mother [124]). As with the FFQ in infancy, the food list was compiled from a variety of sources including: a review of dietary intake data from a nationally representative sample of children aged 3 years [125], the SWS infants [121] , the SWS adults [117], and 3 year old children in the Avon Longitudinal Study of Pregnancy and Childhood [110]. The food list was refined during the piloting stage.

The average frequency of consumption of food and beverage items over the preceding three months was recoded with the following eleven possible responses: (1) never, less than once/month, (2) 1-3 times /month, (3-10) number of times per week, (11) more than once/day (with the option to specify the amount of times per day). Prompt cards with lists of examples of foods included in each food group were used. Portion sizes were recorded in household measures. There was space to record frequency of consumption of foods not listed in the FFQ if they were consumed once a week or more. The amount and type of milk, teaspoons of sugar added to food and drinks and dose and frequency of supplements were also recorded.

At the end of the visit at 3 years, the caregiver was invited to complete a 2 day prospective food diary on behalf of the child which was returned using a prepaid envelope. In this, they recorded all food and drinks consumed by the child from midnight the day following the interview until midnight two days later. Weight, size or household measures were used to quantify the amounts consumed. Details on brand name, meal ingredients and cooking methods were recorded. Dietary supplements during this two day period were also recorded. The relative validity of the FFQ was assessed in comparison to the 2-day food diaries among 892 children in the SWS [124].

The main caregiver also completed an FFQ based on the 3 year FFQ on behalf of the child at 6-7 years. A short FFQ was used to assess diets of children at 8-9 years and 11-13 years.

Table 10.1 Overview of dietary assessment in SWS

Time point	Women 100-item FFQ	Women 24-hour food diary	Child Milk-feeding history	Child FFQ	Child 24-hour recall	Child Food diary
Before pregnancy	✓	✓				
Sub-group of 94 non-pregnant women in repeatability study	✓					
Early pregnancy (11 weeks gestation)	✓	✓				
Late pregnancy (34 weeks gestation)	✓					
Child age 6 months			✓	✓ (34-item)	✓	✓ (4-day diary among validation subsample)
Child age 12 months			✓	✓ (78-item)		✓ (4-day diary among validation subsample)
Child age 3 y				✓ (80-item)		✓ (2-day prospective)
Child age 6-7 y				✓ (80-item)		
Child age 8-9 y				✓*		
Child age 11-13 y				✓*		

All questionnaires used in collecting the dietary data can be found at on the SWS website.

Responses to women's 100-item FFQ based on the preceding three months: never, once every 2-3 months, one per month, once per fortnight, 1-2 times per week, 3-6 times per week, once a day, more than once per day.

At 6 months, the 34-item FFQ was based on the preceding 7 days. Responses were: number of times the food/food group was consumed over the past week, the brand and amount consumed in household measured.

At 12 months, the 78-item FFQ was based on the preceding month. Responses were: never, 1-3 times per month, 1 to 7 times per week, more than once a day.

At 3 years, the 80-item FFQ was based on the preceding three months with the following eleven possible responses: (1) never, less than once/month, (2) 1-3 times /month, (3-10) 1-7 times/week, (11) more than once/day.

* Short FFQ.

10.3 Estimation of nutrient intake

Following the process outlined in section 2.2, where portion sizes were not reported in the FFQs, standard portion sizes were assigned based on children's portion sizes where appropriate. Nutrient intakes were then calculated by multiplying the weight of the portion by its nutrient content as obtained from McCance and Widdowson's the composition of foods 5th edition and its supplements [25, 39, 70, 71].

10.4 Response

Table 10.2 Response to dietary measures in SWS

Phase	Respondent	N interviewed	Response to at least one diet question
Initial Interview	Non-pregnant women	12,583	12,572 FFQ 8,089 Food Diary
Early pregnancy	Women	2,867	2,270 FFQ
Late pregnancy	Women	2,649	2,649 FFQ
6 months	Child	2,959	1,869 FFQ 2,010 24-hour recall
1 y	Child	2,875	2,206 FFQ
3 y	Child	2,625	2,625 FFQ 893 Food Diary
6-7 y	Child	2,034	2,032 FFQ
8-9 y	Child	1,214	1,213 FFQ
11-13 y	Child		1,067 FFQ*

* As of April 2019

10.5 Key findings

Dietary patterns of women

The SWS has a unique study design that facilitates the examination of women's diets both before and during pregnancy as well as their offspring's dietary intake. An interesting

finding from the SWS that takes advantage of the study design, is that women who become pregnant within 3 months of the initial interview were not more likely to comply with recommendations for planning a pregnancy compared to those who did not [126]. Although women who became pregnant reduced smoking, alcohol consumption and caffeinated drinks there was little change in their adherence to fruit and vegetable recommendations [127]. These findings suggest that more work on promoting dietary recommendations for women of childbearing is required.

One of the major pieces of work using these dietary data has been the identification of dietary patterns (DPs). A consistent DP termed the 'prudent' DP was identified using principal component analysis (PCA) of the women's FFQ data. This diet is high in fruit, vegetables, wholemeal bread, pasta, yoghurt and breakfast cereals and low in chips and roast potatoes, sugar, white bread, red and processed meat, full-fat dairy, crisps cakes and biscuits and soft drinks [128]. Higher educational attainment was found to be the most important influence on adherence to the prudent DP [120]. In a subgroup of non-pregnant women, adherence to the prudent DP remained relatively stable over a two year period [115].

Dietary patterns of children

PCA was also applied to the children's FFQ data at 6 and 12 months. The main DP identified was one that is high in fruit, vegetables and home-prepared foods (the 'infant-guidelines' DP). The DPs at 6 and 12 months were correlated and a higher adherence to this DP was associated higher maternal educational attainment, lower maternal BMI, older mothers and those who are non-smokers and watch television less [121]. Children who adhered to this infant-guideline DP were also found to gain weight and skinfold thickness more rapidly from 6 to 12 months [129] and have higher scores for full-scale and verbal IQ at 4 years [130]. Maternal diet was a major influencer on adherence to a prudent DP at 3 years [131].

Validation of DATs

There have been a number of validation studies. In papers comparing dietary data from FFQs among women and children with food diaries, estimated nutrient intakes were slightly higher from FFQs [117, 122, 124]. However, the ranking of individuals in quartiles according to estimated nutrient intakes was similar between FFQ and food diaries [117, 124]. Furthermore when compared to serum vitamin C as a biomarker, the percentage of women classified into the correct quartile for intake was similar for the FFQ and food diaries [117]. The 'prudent' dietary pattern identified using PCA from FFQs and food diaries from women in early pregnancy in the Princess Anne Hospital study was similar, providing further evidence for the ability of the FFQs to accurately classify individuals according to their dietary pattern [132]. The FFQ data from the women were used to derive a shorter 20-item FFQ that has the ability to characterise a prudent dietary pattern which could potentially be used in future studies lacking time and resources and because it limits participant burden, making it easy to use among hard to reach groups [133].

11 Millennium Cohort Study (MCS)

11.1 Summary of cohort

The Millennium Cohort study (MCS), also known as 'Child of the New Century' is the youngest of the UK's birth cohort studies. MCS is a study of all children born between September 2000 and January 2002 in 398 areas across England, Scotland, Wales and Northern Ireland who were alive and living in the UK at 9 months and eligible to receive child benefit [134]. The original sample consisted of 18,552 families (18,827 children). In 2003-2004 during the survey at age three (MCS2), the sample was boosted by families in England who were eligible for inclusion in MCS1 but were missed. The boost brought the total number of children taking part to 19,517 [135]. A stratified cluster sampling framework was used to adequately represent families from disadvantaged areas and ethnic minority groups.

There have been six data collections to date: 9 months, 3, 5, 7, 11 and 14 years. The 17 year data collection was completed in 2019, with the data being made available in mid-to-late 2020. A range of social, economic, demographic and health information have been collected and the data have been linked to administrative data resources.

11.2 Dietary data collection

Information about infant feeding was collected at 9 months (2001), 3 (2004) and 5 (2006) years. Additional information about the children's diets were collected at 5, 7 (2008), 11 (2012) and 14 (2015) years. The main caregiver answered questions on behalf of the child up to age 11. The child themselves responded to the questions at 14 years. All questions were asked during a computer assisted personal interviewing questionnaire (CAPI) during a home visit.

At 9 months, the main caregiver provided information on aspects of infant feeding including breastfeeding and/or formula duration, other types of milk consumed and the introduction of solid foods (access the questionnaire).

At 3 and 5 years, the main caregiver confirmed whether the baby was still breastfeeding and/or the age at which they last had breast milk.

At ages 3, 5, 7, 11 and 14 years, while no established DAT was used, the frequency of consumption of a limited number of specific foods was recorded and these foods varied across sweeps (Table 11.1).

Table 11.1 Diet-related questions in MCS

	2004 Age 3 y	2006 Age 5 y	2008 Age 7 y	2012 Age 11 y	2015 Age 14 y
Does the child eat a portion of fresh fruit or vegetables daily	✓				
How many portions of fresh, frozen tinned or dried fruit consumed per day		✓	✓	✓	
Frequency of at least 2 portions of fruit per day (not including fruit juices)					✓
Frequency of at least 2 portions of vegetables including salad, fresh, frozen or tinned vegetables per day					✓
What type of milk is normally used*					✓
What type of bread is normally eaten†					✓
Frequency of breakfast consumption		✓	✓	✓	✓
If the child eats between meals, what do they usually eat‡		✓	✓		
When the child drinks between meals, what do they usually drink§		✓	✓		
How often does the child drink sweetened drinks				✓	✓
How often does the child drink artificially sweetened drinks				✓	✓
How often, if at all do they eat fast food					✓
Do parents control the diet for specific reasons e.g. allergy, vegetarian, weight control, religion		✓	✓		
Regular mealtimes	✓	✓			
Midday meal provided by school? Free/Paid for?		✓	✓	✓	

Click on headings for links to questionnaire.

Response options:

* Only whole milk/ sometimes whole milk, sometimes semi-skimmed or skimmed milk/ only semi-skimmed milk; sometimes have semi-skimmed, sometimes I have skimmed milk/ only have skimmed milk/ only 1% fat milk/ soya milk or other non-cow milk/ never have milk.

† White bread only/sometimes white, sometimes brown or granary or wholemeal bread (including 50:50 bread)/ only brown/granary bread (including 50:50 bread)/ sometimes brown/granary bread (including 50:50 bread), sometimes wholemeal bread/ only wholemeal bread/ never eat bread.

‡ Crisps and other similar snacks/Breakfast cereal/Cakes and sweet biscuits/Fruit (fresh, dried or tinned)/Vegetables (raw or tinned)/Bread, toast and similar items e.g. crumpets, muffins/Crispbread, crackers, breadsticks, rice cakes etc/Sweets or chocolate/Yoghurt, fromage frais etc./Other dairy products like cheese or eggs /Other (specify)/Does not eat between meals.

§ Sweetened drinks (e.g. cola, squash, sunny delight)/Artificially sweetened drinks (diet cola, sugar-free squash)/Unsweetened or pure fruit juice/Water/Hot drinks (e.g. tea or coffee)/Milk/Milkshakes, hot chocolate and other drinks made with milk/Other.

11.3 Response

Table 11.2 Response to dietary measures in MCS provides the response to dietary questions in MCS. The original cohort consisted of 18,827 children.

Table 11.2 Response to dietary measures in MCS

Year	Age (y)	N interviewed	Response to diet question* n (%)
2001	9 months	18,552	18,527 (99%)†
2004	3 y	15,590	15,445 (99%)‡
2006	5 y	15,246	15,168 (99%)
2008	7 y	13,857	13,782 (99%)
2012	11 y	13,469	13,354 (99%)
2015	14 y	11,884	11,498 (97%)

* Response based on answering at least one of the questions from the questions listed above.
† Based on information about breastfeeding, formula and cow's milk.
‡ Based on information about daily consumption of fruit and vegetables.

11.4 Key findings

Infant feeding

The few papers to date using the dietary data of MCS have focused on infant feeding. Mothers who were in full-time employment and those who returned to work within four months of having their baby were less likely to initiate breastfeeding [136] as were younger mothers of white ethnicity, low levels of education and those in disadvantaged communities [137]. Breastfeeding was found to be associated with a reduced risk of hospitalisations (for diarrhoea or lower respiratory tract infections) as well as with higher measures of cognitive ability at 3, 5, and 7 years [138, 139]. Infants who did not receive

breast milk gained weight faster between birth and 3 years than those who did breastfeed [140]. Similarly, infants who were never breastfed and those who were introduced to solid foods before four months old were more likely to be overweight by three years [141].

Continuing on the theme of risk factors for overweight in childhood, researchers observed that children who had an early introduction to solid foods, fewer portions of fruit per day, who did not regularly eat breakfast and who ate at irregular times were also more likely to be obese at 5 years [142]. Being in the lowest quintile (vs. highest) for family income was associated with being obese at 5 years and diet (skipping breakfast, fruit consumption and sugar-sweetened beverage consumption) explained part of this inequality [143]. Maternal employment was associated with dietary differences among children at 5 years: children of mothers who worked full time were more likely to drink sweetened beverages between meals, less likely to eat fruit or vegetables as a snack or achieve three of more portions of fruit per day at 5 years [144].

12 Harmonisation potential

All of the original eight CLOSER studies have some form of diet-related questions; however the dietary assessment method used and the number of repeat assessments over time varied greatly between the studies. This heterogeneity will make it difficult to create harmonised dietary variables to apply to cross-cohort analyses.

Harmonisation aims to create comparable measures from various types of data across different studies. Harmonisation involves converting variables that capture the same latent construct across studies into a common format and it can be approached in different ways. Maelstrom Research developed guidelines for retrospective data harmonisation.

The DAPA toolkit mentioned in section 2 also provides harmonisation principles from a dietary perspective with these general steps: 1) Define the target variable; 2) Assess

harmonisation potential; 3) Derive common format data. Section 12.1 outlines these steps using the harmonisation of fish intake across 12 studies as an exemplar.

12.1 Exemplar study from InterConnect consortium

The InterConnect consortium was established to examine the causes of diabetes and obesity using existing data. As part of this aim, researchers used exemplar projects to understand challenges and approaches to harmonisation. The DAPA toolkit outlines the approach they took to harmonise fish consumption:

1. Define target variable

The target variable is derived from harmonisation of the raw data in different studies and should be specified in terms of units. This variable should be appropriate to answer the research question as well as being dependent on the data and methods used in the different datasets.

In InterConnect, they aimed to harmonise a total of eight variables (total fish, fatty/oily fish, lean fish, shellfish, saltwater fish, freshwater fish, fried fish, smoked/salted fish), all in g/d, across 12 studies.

2. Assess the harmonisation potential

It is important to know if the existing data have the ability to capture the same latent constructs. Understanding the specific methods and instruments used in each study as well as the format of the data, the overall study design and any assumptions made during processing within-study data are essential.

In InterConnect, ten studies assessed fish intake using FFQs with two using diet history (a retrospective structured interview method consisting of questions about habitual intake of foods from the core food group). While all studies could create total fish, not all could contribute to the seven other variables.

3. Deriving a common format

A number of different methods can be applied to derive a common format for the target variable within each study, for example, using a conversion factor or collapsing to the least common denominator. Applying a conversion factor can be straightforward when the relationship between two units is known, as is the case for converting kilocalories per day to kilojoules per day. Collapsing to the least common denominator can include recoding or transforming existing data and would involve applying an agreed set of rules or algorithms depending on within-study data availability. External data can also be used to support deriving a common format. For example, data on average portion sizes could be used in combination with frequency and food type to derive food quantities. However, this should be applied with caution as the degree to which these values can be generalised depends on the specific study population.

When considering the harmonisation of dietary patterns (DPs), the food groups within each study and the items within these groups should be as similar as possible between the studies. If using PCA to determine a DP, the coefficients from study will need to be applied to the other to ensure the same DP is being compared.

All of these suggested approaches have limitations which might make it difficult to compare absolute levels of dietary intake across studies. However by ranking individuals in quartiles according to intake or adherence to a DP, a comparison of associations between diet and health outcomes between studies can be made.

For the InterConnect consortium, a method to transform variables from each study to the common target variable were created and agreed with each study. Table 12.1 and Table 12.2 outline the harmonisation approach taken. There were some specific challenges related to this study. For instance, for some types of fish it was unclear if they should be classified as lean or fatty. Furthermore, the fat content of certain fish and portion sizes can vary depending on location; therefore local knowledge was required to make these decisions.

Table 12.1 Example of pre-existing data used to derive target variables (FFQ)

(Table adapted from the DAPA Toolkit [145])

Fish items in the original cohort			Harmonised items		
Fish types	**Assumption of g/portion**	**Frequency and quantity**	**Target variable (g/d)**	**Harmonisation - categorisation of fish**	**Harmonisation - frequency and quantity**
White fish (hake, whiting, bream, grouper, sole)	150 g	Frequency: never/almost never; 1-3 times/month; once a week; 2-4 times/week; 5-6 times/week; once per day; 2-3 times/day; 4-6 times/day; more than 6 times/day	Lean fish	White fish/day + Cod/day	Lean fish: multiply portion/day*150 g
Cod	150 g				
Blue fish (sardines, tuna, bonito, mackerel, salmon)	150 g		Fatty fish	Blue fish/day	Fatty fish: multiply portion/day*150 g
Salted or smoked fish	50 g		Salted/smoked/dried	Salted or smoked fish/day	Salted/smoked/dried fish: multiply portion/day*50 g
Clam, oyster, mussels	60 g		Seafood other than fish	Total seafood per day	Source data already in g/d
Prawn, king prawn, crayfish	100 g				

Fish items in the original cohort			Harmonised items		
Octopus, squid, cuttlefish	150 g				
Total fish and seafood per day (derived)		g/d	Total fish	Total fish and seafood per day	Source data already in g/d
Total seafood per day (derived)		g/d			

Table 12.2 Example of pre-existing data used to derive target variables (diet history)

(Table adapted from the DAPA Toolkit [145])

Fish items in the original cohort		Harmonised items		
Fish types	**Frequency and quantity**	**Target variable**	**Harmonised categorisation of fish**	**Harmonised frequency and quantity**
Total fish	g/d	Total fish	Total fish (sum of all available variables) - variables are mutually exclusive	Source data already in g/d
Cod; Baltic herring with bones; Baltic herring; Salmon; Salmon salted; Baltic herring salted with bones; Herring slated; Smoked Baltic herring with bones; Sardine; Smoked redfish; Perch; Pike; Flounder; Bream; Vendace with bones; Fresh frozen saithe; Whitefish; Fish average; Fish in soup, average; Roe; Stockfish; Vendace, salted with bones; Smoked vendace with bones; Smoked lamprey; Smoked whitefish; Smoked fish average; Tuna; Shrimp	g/d	Lean fish	Cod; Stockfish; Fresh frozen saithe; Perch; Pike; Flounder; Fish, average; Fish in soup, average	Source data already in g/d
		Fatty fish	Baltic herring with bones; Baltic herring; Salmon; Salmon salted; Baltic herring salted with bones; Herring slated; Smoked Baltic herring with bones; Sardine; Smoked redfish; Whitefish; Vendace, salted with bones; Smoked vendace with bone; Vendace, with bones; Smoked fish average	Source data already in g/d
		Salted/ smoked/ dried	Salmon salted; Baltic herring salted with bones; Herring salted; Smoked Baltic herring with bone; Smoked redfish; Vendace, salted with bones; Smoked vendace with bone; Smoked lamprey; Smoked whitefish; Smoked fish average: mean of four species; Baltic herring smoked; Vendace smoked; Whitefish smoked; Bream smoked	Source data already in g/d

Fish items in the original cohort		Harmonised items		
		Seafood other than fish	Shrimps	Source data already in g/d

There are no specific rules for harmonising dietary data across studies. The approach taken depends on the research question and the data available. A metadata inventory documenting methods, data formats and nuances of data processing etc. is the most time consuming aspect of harmonisation. With this guide, we have completed this key step for the original CLOSER partner studies, so that researchers can focus on how best to answer their specific diet-related questions.

13 Conclusions

The UK is home to a large number of richly characterised longitudinal studies that can help inform understanding of population trajectories over the entire life course in changing contexts.

The purpose of this guide was to catalogue what dietary information is available in the original CLOSER partner studies and to provide researchers with an overview of some measurement and contextual issues that should be considered when planning and conducting their analyses. It is hoped that this guide will encourage and help future researchers address pertinent diet-related research questions across the studies.

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