CORA Cork Open Research Archive
Cartlann Taighde Oscailte Chorcaí

Title	A systematic review of methods to assess intake of fruits and vegetables among healthy European adults and children: a DEDIPAC (DEterminants of DIet and Physical Activity) study
Authors	Riordan, Fiona;Ryan, Kathleen;Perry, Ivan J.;Schulze, Matthias B.;Andersen, Lene Frost;Geelen, Anouk;Van't Veer, Pieter;Eussen, Simone;Dagnelie, Pieter;Wijckmans-Duysens, Nicole;Harrington, Janas M.
Publication date	2016-09-14
Original Citation	Riordan, F., Ryan, K., Perry, I.J., Schulze, M.B., Andersen, L.F., Geelen, A., van't Veer, P., Eussen, S., Dagnelie, P., Wijckmans-Duysens, N. and Harrington, J.M. (2016) 'A systematic review of methods to assess intake of fruits and vegetables among healthy European adults and children: a DEDIPAC (DEterminants of DIet and Physical Activity) study', Public Health Nutrition [In Press], pp. 1–32. doi: 10.1017/S1368980016002366.
Type of publication	Article (peer-reviewed)
Link to publisher's version	https://www.cambridge.org/core/journals/public-health-nutrition - 10.1017/S1368980016002366
Rights	© The Authors 2016.
Download date	2026-11-16 07:01:52
Item downloaded from	https://hdl.handle.net/10468/3232

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Public Health Nutrition: page 1 of 32 doi:10.1017/S1368980016002366

A systematic review of methods to assess intake of fruits and vegetables among healthy European adults and children: a DEDIPAC (DEterminants of DIet and Physical Activity) study

Fiona Riordan[1,*], Kathleen Ryan[2], Ivan J Perry[1], Matthias B Schulze[3], Lene Frost Andersen[4], Anouk Geelen[5], Pieter van't Veer[5], Simone Eussen[6], Pieter Dagnelie[6], Nicole Wijckmans-Duysens[6] and Janas M Harrington[1]

[1]Department of Epidemiology and Public Health, University College Cork, Western Road, Cork, Republic of Ireland: [2]School of Applied Psychology, University College Cork, Cork, Republic of Ireland: [3]Department of Molecular Epidemiology, German Institute of Human Nutrition, Potsdam-Rehbrücke, Germany: [4]Department of Nutrition, Institute of Basic Medical Sciences, University of Oslo, Oslo, Norway: [5]Division of Human Nutrition, Wageningen University, Wageningen, The Netherlands: [6]Department of Epidemiology of the Faculty of Health, Medicine and Life Sciences, Maastricht University, Maastricht, The Netherlands

Submitted 24 September 2015: Final revision received 22 July 2016: Accepted 29 July 2016

Abstract

Objective: Evidence suggests that health benefits are associated with consuming recommended amounts of fruits and vegetables (F&V), yet standardised assessment methods to measure F&V intake are lacking. The current review aims to identify methods to assess F&V intake among children and adults in pan-European studies and inform the development of the DEDIPAC (DEterminants of DIet and Physical Activity) toolbox of methods suitable for use in future European studies.

Design: A literature search was conducted using three electronic databases and by hand-searching reference lists. English-language studies of any design which assessed F&V intake were included in the review.

Setting: Studies involving two or more European countries were included in the review.

Subjects: Healthy, free-living children or adults.

Results: The review identified fifty-one pan-European studies which assessed F&V intake. The FFQ was the most commonly used (*n* 42), followed by 24 h recall (*n* 11) and diet records/diet history (*n* 7). Differences existed between the identified methods; for example, the number of F&V items on the FFQ and whether potatoes/legumes were classified as vegetables. In total, eight validated instruments were identified which assessed F&V intake among adults, adolescents or children.

Conclusions: The current review indicates that an agreed classification of F&V is needed in order to standardise intake data more effectively between European countries. Validated methods used in pan-European populations encompassing a range of European regions were identified. These methods should be considered for use by future studies focused on evaluating intake of F&V.

Keywords
Fruits and vegetables
Dietary assessment
Europe
DEDIPAC

A poor diet is associated with four major non-communicable diseases: cancer, CVD, diabetes and respiratory disorders[1–4], which account for approximately 60 % of deaths globally per annum[5]. There is a growing body of research which highlights the benefits of fruit and vegetable (F&V) consumption, including the protective effect of F&V consumption on CVD[6,7]. The WHO Global Strategy on Diet and Physical Activity has made several key recommendations with respect to dietary intake, including increasing F&V consumption[8]. In the 2004 joint report of the FAO/WHO Workshop on Fruit and Vegetables for Health, the WHO outlined a framework for developing interventions to promote adequate consumption of F&V in Member States[9].

However, in order to develop and assess such interventions, and moreover to monitor the consumption of

*Corresponding author: Email fiona.riordan@ucc.ie

© The Authors 2016

Downloaded from http://www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http://www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

F&V worldwide, reliable and comparable assessment methods are essential[10,11]. Methodological differences between studies which assess the intake of F&V, including differences in the units of serving size and frequency, and the definition of what constitutes a fruit or vegetable, can often hinder meaningful comparisons[12]. As highlighted by Roark *et al.*[12], the definition of vegetables poses a particular problem. Debate focuses on whether legumes, pulses and/or potatoes are considered to be vegetables[10,12] and whether fruits should include nuts, olives and fruit juices which are 100 % juice[10]. While F&V can be defined by their nutritional content as 'low energy-dense foods, relatively high in vitamins, minerals, and other bioactive compounds as well as being a good source of fibre'[10] (p. 4), there is no agreed understanding of 'fruit' or 'vegetable' in terms of how they should be captured through dietary assessment methods; that is, what is considered a fruit or vegetable in one country may not be in another. This disparity may create issues when measuring and tracking intake across different regions[10].

Previous and existing European projects have focused on the standardisation and harmonisation of food classification systems and food composition databases between countries (e.g. the International Food Data Systems Project, the Eurofoods initiative, the Food-Linked Agro-Industrial Research programme, COST Action 99, TRANSFAIR study, EUROFIR, etc.)[11,13–18] and the IDAMES (Innovative Dietary Assessment Methods in Epidemiological Studies and Public Health) project has evaluated new-generation methods to assess dietary intake in Europe[19], developing the European Food Propensity Questionnaire for use within European countries. Guidelines from the European Food Safety Authority recommend the use of a computerised method (e.g. EPIC-SOFT or similar) for collection of accurate, standardised, food consumption data at the European level[20,21]. However, standards have not, as yet, been developed for the assessment of dietary intake, including intake of F&V, as part of aetiological studies. Thematic Area 1 of the DEDIPAC (DEterminants of DIet and Physical Activity) project[22] aims to address this gap and add to our understanding of the most effective, harmonised methods of dietary intake assessment by preparing a toolkit of the most useful measurement tools of dietary intake that can be used extensively across Europe[22,23]. The aim of the current systematic literature review was to identify suitable assessment methods that may potentially be used to measure intake of F&V in European children and adults in pan-European studies.

Materials and methods

Data sources and study selection

The current review adheres to the guidelines of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Statement. The protocol for the review can be accessed from PROSPERO (CRD42014012947)[24]. A systematic literature search for pan-European studies that assessed the intake of F&V was conducted. For this review, we used the definition of F&V proposed by Agudo[10]: 'vegetables and foods used as vegetables', with fruits taken to be fresh or preserved fruits. Our definition included nuts, legumes and potatoes, and only 100 % fruit juice was considered a fruit. Legumes and potatoes are not consistently included as vegetables across dietary assessment methods; therefore, where possible, it was reported whether the instrument in question excluded or included these items as vegetables. Two authors, F.R. and K.R., independently conducted a search of PubMed, EMBASE and Web of Science databases, using combinations of the following search terms: 'fruit/s' and 'vegetable/s', with keywords for dietary intake, including 'diet', 'eating', 'consumption', 'intake', and search terms for European countries. A full copy of the EMBASE search strategy is presented in the online supplementary material, Supplemental Table 1. All searches were limited to English-language literature published from 1990 through to 7 July 2014.

Titles and abstracts of the sourced articles were independently screened by F.R. and K.R. If in doubt regarding inclusion, the article was retained for full-text review. Any disagreement during the full-text review stage was resolved through consultation with a third author, J.M.H. Studies were included if they assessed the intake of F&V within two or more European countries, as defined by the Council of Europe[25]. Participants were required to be free-living, healthy populations of any age; therefore we excluded hospital-based populations and studies which focused on a specific disease subgroup (e.g. diabetic cohort) or any fixed societal subgroups (e.g. pregnant women). The review was not limited to certain study designs. If studies compared two groups, one of which was a healthy general population, they were included. Intervention studies were eligible if F&V intake was measured at baseline before any dietary intervention was undertaken. Similarly, case–control studies were included if intake was assessed in population-based controls. Studies were included only if they assessed intake of F&V at the level of the individual; that is, those which assessed household-level consumption of F&V were excluded (Fig. 1).

Reference lists of all included papers, along with relevant meta-analysis and literature reviews, were reviewed for further publications not identified by the original search. Databases were also searched using the names of individual European projects listed in the DEDIPAC Inventory of Relevant European Studies, a compilation which is an ongoing part of DEDIPAC. Authors were contacted to obtain full versions of the relevant instruments or questionnaires and some articles; and the Endnote library of a concurrently occurring systematic literature review on methods to assess intake of sugar-sweetened beverages was reviewed for further studies.

Downloaded from http:/www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http:/www.cambridge.org/core/terms.
http://dx.doi.org/10.1017/S1368980016002366

Data extraction and quality assessment

Data extraction was carried out using a form that was developed, piloted and subsequently revised to capture the following data: study design; number and names of European countries involved; sample size (total and number for each country); age range of the included population; the method used and description (including frequency categories for FFQ, number of items/items that referred to F&V, details of portion estimation); mode of administration; and details on the validation or reproducibility. Originally sourced articles which described the assessment methods in the most detail were selected for inclusion in the review, with further information on the methods obtained from articles sourced from reference lists. One reviewer extracted the data for each study, which was confirmed by the other reviewer.

The aim of the current systematic literature review was to identify and describe assessment methods that have been used to assess intake of F&V. Therefore, a comprehensive quality appraisal of each included article was not conducted as part of the current review. However, it was recorded whether or not the instrument in question had been tested for validity and/or reproducibility, and relevant validation studies were referenced where possible. Data were extracted from these studies by P.D., S.E. and N.W.-D. to inform the instrument selection. In order to determine which instruments would be appropriate to use in pan-European studies, two selection criteria were applied: (i) the instrument was reviewed for validity and/or reproducibility, of which a summary of its indicators is presented; and (ii) the instrument was used in more than two countries simultaneously that represented a range of European regions. A 'range' meant that at least one country from at least three of the Southern, Northern, Eastern and Western European regions, as defined by the United Nations, were included[26]. The results of this selection are shown in Table 1.

Results

Description of the included studies

As shown in Fig. 1, 5678 papers remained once duplicates were removed, and 167 were retained after screening titles and abstracts and following full-text screening.

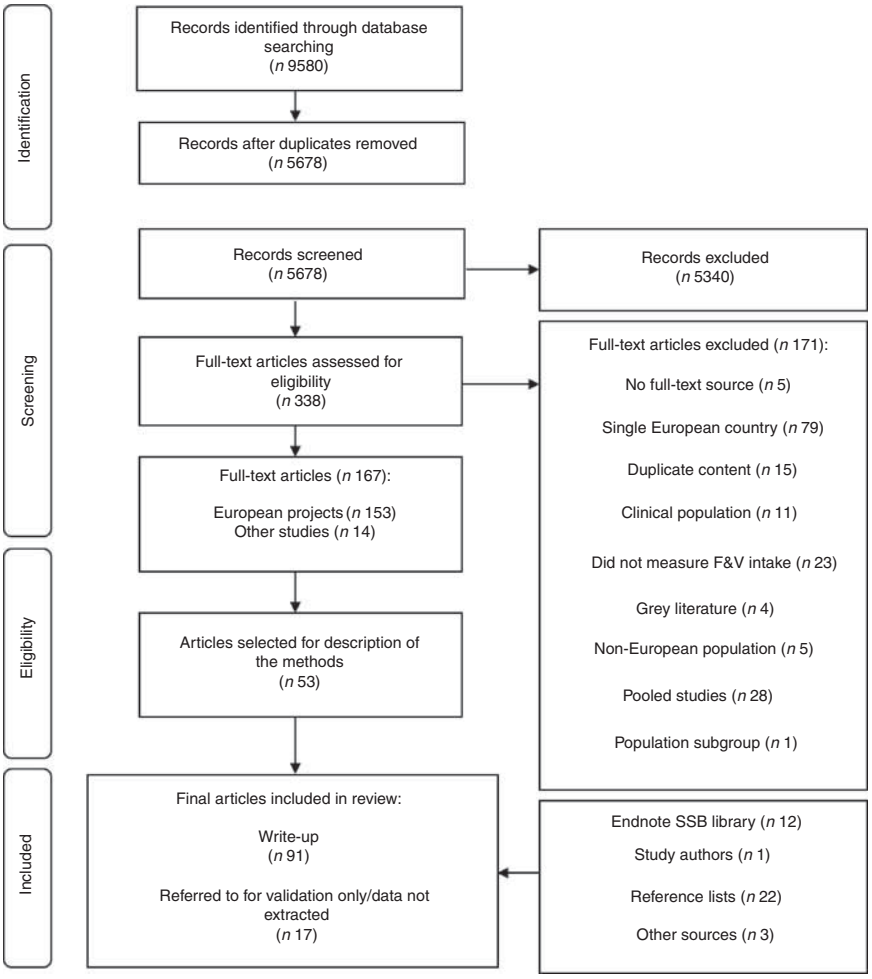


Fig. 1 Flow diagram showing study selection process for the current review (F&V, fruit and vegetable; SSB, sugar-sweetened beverages)

Downloaded from http:/www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http:/www.cambridge.org/core/terms.
http://dx.doi.org/10.1017/S1368980016002366

These articles were grouped according to the major European project to which they belonged (*n* 153) or grouped as 'Other' (*n* 14) if they did not belong to a project. From these 167 articles, fifty-three articles were selected, typically one to three articles per project, which best described the background to the project or the methods used (Fig. 1).

Reviewing the reference lists yielded twenty-two further articles in which the methods were described[18,27–47]. Twelve further articles were obtained from the Endnote library on sugar-sweetened beverages in which two additional studies assessing the intake of F&V, the ToyBox study and a study by Kolarzyk *et al.*[48], were described. One article was obtained from authors[49]. Unpublished details on the instruments used as part of the I.Family Project[50], the IDEFICS (Identification and prevention of Dietary- and lifestyle-induced health EFfects In Children and infantS) study follow-up, were obtained through contact with the IDEFICS group. Articles on the background and validation of the Food4Me project, published after the search dates, were also added to the review[51–53]. The term 'study' is used in the current review to refer to the larger project, rather than individual analyses/publications that may arise from the same project, and therefore use the same methodology.

Taking together the articles sourced and selected from our original search (*n* 53), from reference lists (*n* 22), from the concurrent review on sugar-sweetened beverages (*n* 12), from authors (*n* 1) and articles added subsequently (*n* 3), a total of ninety-one articles covering fifty-one studies were included in the review. For each of the methods identified, article(s) which described the validation or reliability testing performed for that method were recorded. As a result, seventeen further articles were sourced in which validation and/or reliability testing for the identified methods was described. The characteristics of the included studies[4,18,27–48,50–145] are described in Table 2.

From the sourced articles, fifty-one pan-European studies in total were identified: thirty-five named projects and sixteen smaller projects[48,54,56,65,69,72,82,83,88,93,94,107,109,113,114,116]. Most studies assessed dietary intake of F&V among adults[18,41,44,46,48,50,51,54–57,59,60,64–66,68,69,71,72,75–79,81–84,86,88,92–94,107,146,147]. Five assessed parents or caregivers[27,50,85–87,102]. Four studies examined intake among older adults, namely MEDIS (MEDiterranean Islands Study)[78], the Seven Countries Study[4,91,92], SENECA (Survey in Europe on Nutrition and the Elderly; a Concerted Action)[43,90,148,149] and the 'Food in later life' study[68]. Nine studies assessed intake among children[27,30,37,50,85,86,101,116,120] in age ranges 2–9 years[37,118,119], 3–6 years[95–106], 2–11 years[50], 7–11 years[116], 11 years[85] and 10–12 years[27], and seven assessed intake among adolescents[32,50,109,110,113–115].

Validation

Table 2 provides detail on the instruments' validation. Of the studies which were validated or tested for reproducibility and fulfilled inclusion criterion 1 (Table 1), validity and reliability of the FFQ was assessed using biomarkers[63,126], FFQ[52], food records[42,53,80,128–132,137,138] or 24 h recalls (24-HDR)[36,38,80,129,135] as the reference method. In fifteen studies, validity was assessed by crude correlations[35,36,38,42,53,63,80,126,128,130,132,137,138], energy-adjusted correlations[52,53,126,129], de-attenuated correlation coefficients[36,38,129,137], mean or median differences in F&V consumption[35,36,38,42,52,53,80,126,128–130,132,137,138], exact level of agreement of F&V consumption[38,42,52,53,80,126,130,132,137,138], Bland–Altman plots[36,52,53,129] or weighted kappa[38,137] between the FFQ and reference instrument. In nine studies, reliability of F&V consumption was assessed by correlations[36,42,53,80,131,132,137,145], mean/median differences[36,80,137,138,145], weighted kappa[132,138,145] or intraclass correlation coefficients[137] between subsequent assessments of the FFQ. Where available, data were extracted and are provided in detail in the online supplementary material, Supplemental Table 2.

Dietary intake assessment methods

Types of methods

Several methods were used to assess dietary intake of F&V in the identified studies. The vast majority of the pan-European studies used FFQ (*n* 42)[27,29,30,36,41,48,50,52,54–56,58–60,64–66,69,71,72,75,76,78,79,82,84–86,88,93,104,109,110,113–116,120,139,146,150]. Since a common FFQ instrument was not used across all countries in the EPIC (European Prospective Investigation into Cancer and Nutrition) study, only the EPIC-SOFT instrument is discussed in the current review.

According to the two selection criteria (i.e. whether tested for validity or reproducibility and used in more than two countries representing a range of European regions; Table 1), six instruments were appropriate to assess intake of F&V in future pan-European studies among adults: EPIC-SOFT, the Food4Me FFQ, the ToyBox Primary Caregiver's Questionnaire, the ENERGY (EuropeaN Energy balance Research to prevent excessive weight Gain among Youth) parent questionnaire, and the dietary history methods used by the SENECA study and Seven Countries Study. Three instruments used to assess intake among adolescents, HELENA-DIAT (Healthy Lifestyle in Europe by Nutrition in Adolescence–Dietary Assessment Tool), HELENA online FFQ and the HBSC (Health Behaviour in School-aged Children) FFQ, fulfilled the criteria. The ENERGY children's questionnaire and the instruments used by the IDEFICS, Pro-Children and ToyBox studies appeared appropriate to measure F&V among children. Although not validated separately, the I.Family instruments were based closely on those of the IDEFICS study and also met the criteria. The 24-HDR preceded by the 1 d qualitative food record used in the EYHS (European Youth Heart Study) was a validated method but not tested in the study population[144]. While Table 1 indicates the selected

Downloaded from http:/www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http:/www.cambridge.org/core/terms.
http://dx.doi.org/10.1017/S1368980016002366

Downloaded from http://www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http://www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

Table 1 Identified instruments according to criteria. Instruments which meet both criteria are shaded

Study	Countries	Instrument(s)	Validated	>2 countries/ country range
Adults				
Baldini *et al.*[54]	2 (Italy, Spain)	FFQ	X[53]	
Baltic project[55]	3 (Latvia, Lithuania, Estonia)	24-HDR Standardised questionnaire		
Behanova *et al.*[56]	2 (Slovakia, Netherlands)	FFQ		
CNSHS[57,58]	4 (Germany, Denmark, Poland, Bulgaria)	FFQ		X
ECRHS[59]	3 (Germany, UK, Norway)	FFQ (based on EPIC-UK and EPIC-Germany FFQ)	X[59]	
EHBS[60]	21 in total 17 European countries (Austria, Denmark, England, Finland, France, Germany, Greece, Iceland, Ireland, Netherlands, Norway, Poland, Portugal, Scotland, Spain, Sweden, Switzerland)	FFQ		X
ENERGY[27]	7 (Belgium, Greece, Hungary, Netherlands, Norway, Slovenia, Spain)	FFQ	X[28]	X
EPIC[18,28,29,61,62]	10 (Italy, Spain, Netherlands, Germany, Sweden, Denmark, France, Greece, Norway, England)	24-HDR (EPIC-SOFT)	X[63]	X
ESCAREL[64]	7 (France, Spain, Italy, UK, Finland, Latvia, Estonia)	FFQ		X
Esteve *et al.*[65]	4 (Spain, Italy, Switzerland, France)	Dietary questionnaire		
Finbalt Health Monitor[66]	4 (Estonia, Finland, Latvia, Lithuania)	FFQ		
Finnish and Russian Karelia study[67] (2002 study)	2 (Russia, Finland)	FFQ		
Food4Me[51,53]	7 (Ireland, Netherlands Spain, Greece, UK, Poland, Germany)	FFQ (web-based)	X[52,53]	X
'Food in later life' project[68]	8 (Denmark, Germany, Italy, Poland, Portugal, Spain, Sweden, UK)	7 d non-weighed food diaries		X
Galanti *et al.*[69]	2 (Sweden, Norway)	FFQ		
North/South Food Consumption Survey[45,81]	2 (Northern Ireland, Republic of Ireland)	7 d record		
HAPIEE[70]*	3 (Russia, Poland, Czech Republic)	FFQ	X[126,127]	
HTT[71]	9 (Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Ukraine)	FFQ		
Hupkens *et al.*[72]	3 (Belgium, Netherlands, Germany)	FFQ	X[128]	
I.Family Project[50,73,74]	8 (Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain, Sweden)	Diet questionnaire (FFQ) which was included as part of the parent questionnaire Online 24-HDR (SACANA)		X
IHBS[75]	17 (Austria, Denmark, England, Finland, France, Germany, Greece, Iceland, Ireland, Netherlands, Norway, Poland, Portugal, Scotland, Spain, Sweden, Switzerland)	FFQ		X
IMMIDIET[76]	3 (Italy, Belgium, England)	EPIC-Italian FFQ EPIC-UK FFQ Specifically developed Belgian FFQ	X[39,129]	
Kolarzyk *et al.*[48]	4 (Poland, Belarus, Russia, Lithuania)	FFQ	X	
LiVicordia[77]	2 (Lithuania, Sweden)	24-HDR		
LLH[71]	8 (Armenia, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Ukraine)	FFQ		
MEDIS[78]	2 (Cyprus, Greece)	FFQ	X[138]	
MGSD[79]	6 (Greece, Italy, Algeria, Bulgaria, Egypt, Yugoslavia (only diabetics in Yugoslavia))	Dietary history method using questionnaire	X[79]	
NORBAGREEN[41,80]	8 (Norway, Denmark, Sweden, Finland, Latvia, Lithuania, Estonia, Iceland)	FFQ	X[80]	
O'Neill *et al.*[82]	5 (UK, Republic of Ireland, Spain, France, Netherlands)	FFQ		X
Parfitt *et al.*[83]	2 (England, Italy)	5–7 d record		
PRIME[84]	2 (Northern Ireland, France)	FFQ	X	
PRO GREENS[85]	10 (Austria, Belgium, Denmark, Iceland, Netherlands, Norway, Portugal, Spain, Sweden, Finland)	A pre-coded 24-HDR, FFQ (parents)		X
Pro-Children study[42,86,87]	9 (Austria, Belgium, Denmark, Iceland, Netherlands, Norway, Portugal, Spain, Sweden)	A pre-coded 24-HDR, FFQ (parents)	X[130]	X
Rylander *et al.*[88]	2 (Sweden, Switzerland)	FFQ		
SENECA[43,44,89,90]	12 (Belgium, Denmark, France, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Spain, Switzerland)	Modified dietary history method comprising a 3 d estimated record and meal-based frequency checklist	X[89]	X

Downloaded from http://www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http://www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

Table 1 *Continued*

Study	Countries	Instrument(s)	Validated	>2 countries/ country range
Seven Countries Study[4,91,92]	7 (Netherlands, Finland, Yugoslavia, Japan, Italy, Greece, USA)	Cross-check dietary history method European cohorts (*n* 14) used 7 d records at baseline	X[131]	X
Terry *et al.*[93]	6 (Germany, France, Canada, Sweden, Australia, USA)	FFQ		
Tessier *et al.*[94]	2 (Malta, Italy)	Open-ended qualitative questionnaire		
ToyBox[95–106]	6 (Belgium, Bulgaria, Germany, Greece, Poland, Spain)	Primary caregiver's FFQ (PCQ)	X[100]	X
Van Diepen *et al.*[107]	2 (Greece, the Netherlands)	2× consecutive 24-HDR		
WHO-MONICA EC/ MONICA Project optional nutrition study[46,108]	9 (Northern Ireland, UK (Cardiff), Denmark, Finland, Belgium, Germany, France, Italy, Spain)	3 d record and 7-d record. One centre used 3× 24-HDR		X
Adolescents				
Gerrits *et al.*[109]	3 (Netherlands, Hungary, USA)	FFQ		
HBSC[31,110]	37 (England, Norway, Macedonia, Iceland, Netherlands, Portugal, Wales, Italy, Sweden, Latvia, Switzerland, Denmark, Estonia, Scotland, Slovenia, Ukraine, Belgium, Finland, Greece, Croatia, Hungary, Lithuania, Poland, Germany, Greenland, Russia, Armenia, Austria, Belgium, Spain, France, Romania, Turkey, Czech Republic, Ireland, Luxembourg, Slovakia)	FFQ	X[132]	X
HELENA[32–36,47,111,112]	9 (Greece, Germany, Belgium, France, Hungary, Italy, Sweden, Austria, Spain) 8 countries included for 24-HDR (as above, except Hungary) 5 (Austria, Belgium, Greece, Sweden, Germany) pilot-tested the online FFQ	24-HDR HELENA-DIAT (Dietary Assessment Tool) Online FFQ	X[34,35]	X
Larsson *et al.*[113]	2 (Sweden, Norway)	FFQ		
Szczepanska *et al.*[114]	2 (Poland, Czech Republic)	FFQ		
TEMPEST[115]	4 (Netherlands, Poland, UK, Portugal)	FFQ		X
Children				
Antova *et al.*[116]	6 (Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia)	FFQ		
ENERGY[27]	7 (Belgium, Greece, Hungary, Netherlands, Norway, Slovenia, Spain)	Questionnaire with FFQ and 24-HDR	X[133]	X
EYHS[30,117]	4 (Denmark, Portugal, Estonia, Norway)	24-HDR, qualitative food record	X†	
IDEFICS[37,38,135,139,140,145]	8 (Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain, Sweden)	CEHQ-FFQ SACINA 24-HDR[50]	X[35,38,134,135,140,145]	X
I.Family Project[50]	8 (Belgium, Cyprus, Estonia, Germany Hungary, Italy, Spain, Sweden)	Diet Questionnaire (FFQ) as part of children's questionnaire Online 24-HDR (SACANA)	X*	X
ISAAC Phase II[40,120]	15 (Albania, France, Estonia, Germany, Georgia, Greece, Iceland, Italy, Latvia, Netherlands, Norway, Spain, Sweden, Turkey, UK)	FFQ*		X
PRO GREENS[85]	10 (Austria, Belgium, Denmark, Iceland, Netherlands, Norway, Portugal, Spain, Sweden, Finland)	A pre-coded 24-HDR, FFQ		X
Pro-Children study[42,86,87]	9 (Austria, Belgium, Denmark, Iceland, Netherlands, Norway, Portugal, Spain, Sweden)	A pre-coded 24-HDR, FFQ	X[42,136]	X
ToyBox[95–106]	6 (Belgium, Bulgaria, Germany, Greece, Poland, Spain)	Children's FFQ	X[137]‡	X

CNSHS, Cross National Student Health Survey; ECRHS, European Community Respiratory Health Survey; EHBS, European Health and Behaviour Survey; ENERGY, EuropeaN Energy balance Research to prevent excessive weight Gain among Youth; EPIC, European Prospective Investigation into Cancer and Nutrition; ESCAREL, European Study in Non Carious Cervical Lesions; HAPIEE, Health, Alcohol and Psychosocial factors in Eastern Europe; HTT, Health in Times of Transition; IHBS, International Health and Behaviour Survey; LLH, Living Conditions, Lifestyles and Health; MEDIS, MEDiterranean Islands Study; MGSD, Mediterranean Group for the Study of Diabetes; PRIME, Prospective Epidemiological Study of Myocardial Infarction; SENECA, Survey in Europe on Nutrition and the Elderly; a Concerted Action; MONICA, Multinational MONItoring of trends and determinants in CArdiovascular disease; HBSC, Health Behaviour in School-aged Children; HELENA, Healthy Lifestyle in Europe by Nutrition in Adolescence; TEMPEST, 'Temptations to Eat Moderated by Personal and Environmental Self-regulatory Tools'; EYHS, European Youth Heart Study; IDEFICS, Identification and prevention of Dietary- and lifestyle-induced health EFfects In Children and infantS; ISAAC, International Study of Asthma and Allergies in Childhood; 24-HDR, 24 h recall; PCQ, Primary Caregiver's Questionnaire; CEHQ, Children's Eating Habits Questionnaire.
*Based on the IDEFICS instruments which were validated.
†24-HDR and qualitative 1 d food record method has been validated but not as part of the EYHS.
‡The reliability study on the FFQ is unpublished.

Downloaded from http://www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http://www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

Table 2 Summary of the included studies: design, population studied, dietary assessment instruments used and details of validation and/or reproducibility. Studies selected according to the two criteria are shaded. Where validation or reliability data was not available for fruit and vegetables specifically, this is highlighted in bold font

Study	Design	Population	Countries	Instrument(s)	Validation	Reproducibility
Adults						
Baldini *et al.*[54]	Cross-sectional	Adults/students (*n* 210) Age range NR	2 (Italy, Spain)	FFQ	Based on the Willett FFQ Validated against diet records[124] **No validation data for F&V**	No details‡
Baltic project[55]	Cross-sectional	Adults (*n* 4571) 19–65 years	3 (Latvia, Lithuania, Estonia)	24-HDR Standardised questionnaire	No details‡	No details‡
Behanova *et al.*[56]	Cross-sectional	Adults (*n* 210) 19–64 years	2 (Slovakia, Netherlands)	FFQ†	No details‡	No details‡
CNSHS[57,58]	Cross-sectional	Adults/students (*n* 2651) Age range NR	4 (Germany, Denmark, Poland, Bulgaria)	FFQ	No test of validity was performed, but the questionnaire was similar to other FFQ that have been validated	
ECRHS[59]	Cross-sectional	Adults (*n* 1174) 30–70 years	3 (Germany, UK, Norway)	FFQ (based on EPIC-UK and EPIC-Germany FFQ)	German and UK FFQ validated against 24-HDR[125,141] The Norwegian FQ was not assessed for repeatability or validity	Reproducibility of German FFQ obtained by a repeated administration of the FFQ at a 6-month interval[125]. Repeatability of the UK FFQ using two assessments separated by an interval of 5–23 months[59]
EHBS[60]	Cross-sectional	Adults/students (*n* 7115) 17–30 years	21 in total 17 European countries (Austria, Denmark, England, Finland, France, Germany, Greece, Iceland, Ireland, Netherlands, Norway, Poland, Portugal, Scotland, Spain, Sweden, Switzerland)	FFQ†	No details‡	Reliability of the measures are described[142] but **no reliability data on F&V**
ENERGY[27]	Cross-sectional	Adults/parents or guardians (*n* 6002) Age range NR	7 (Belgium, Greece, Hungary, Netherlands, Norway, Slovenia, Spain)	FFQ†	No details‡	The reliability and content validity of the parent questionnaires were tested separately in all participating countries, in five schools per country using approximately fifty parents per country for the reliability study and twenty parents for the construct validity study (unpublished results)
EPIC[18,28,29,61–63]	Cohort	Adults (*n* 519 978) 30–70 years	10 (Italy, Spain, Netherlands, Germany, Sweden (Malmo)/Sweden (Umea), Denmark, France, Greece, Norway, England)	FFQ†, 24-HDR (EPIC-SOFT)	EPIC-SOFT was validated against biomarkers for F&V consumption[63] Assessed by crude correlations Weak to moderate association between biomarkers and F&V intake	No details‡
ESCAREL[64]	Cross-sectional	Adults (*n* 3187) 18–35 years	7 (France, Spain, Italy, UK, Finland, Latvia, Estonia)	FFQ†	Bartlett *et al.*[64] report that all questionnaires were validated in pilot studies **No reference or data available**	
Esteve *et al.*[65]	Case–control	Adults/controls (*n* 3057) Age range NR	4 (Spain, Italy, Switzerland, France)	Dietary questionnaire	No details‡	No details‡
Finbalt Health Monitor[66]	Cross-sectional	Adults (*n* 25 044) 20–64 years	4 (Estonia, Finland, Latvia, Lithuania)	FFQ†	No details‡	No details‡

Downloaded from http://www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http://www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

Table 2 *Continued*

Study	Design	Population	Countries	Instrument(s)	Validation	Reproducibility
Finnish and Russian Karelia study[67] (2002 study)	Cross-sectional	Adults (*n* 1201) 25–64 years	2 (Russia, Finland)	FFQ†	No details‡	No details‡
'Food in later life project'[68]	Cross-sectional	Adults (*n* 644) 65–98 years	8 (Denmark, Germany, Italy, Poland, Portugal, Spain, Sweden, UK)	7 d non-weighed food diaries	No details‡	No details‡
Food4Me[51–53]	Randomised controlled trial	Adults (*n* 5562) 17–79 years	7 (Ireland, Netherlands, Spain, Greece, UK, Poland, Germany)	FFQ (web-based)	Validated against 4 d non-consecutive weighed records[53] and by comparing with the validated EPIC-Norfolk FFQ[52] Assessed by crude correlations, energy-adjusted correlations, and mean or median differences in F&V consumption Moderate agreement with 4 d weighed food record	Interval: 4 weeks[53] Assessed by correlations Reproducible for nutrient and food group intake
Galanti *et al.*[69]	Cross-sectional	Adults (*n* 440)	2 (Sweden, Norway)	FFQ†	No details‡	No details‡
HAPIEE[70]*	Cross-sectional	Adults (*n* 28 947)	3 (Russia, Poland, Czech Republic)	FFQ†	Based on the Whitehall II questionnaire. Validated against a 7 d diet diary and biomarkers of nutrient intake by Brunner *et al.*[126]. Whitehall II questionnaire was originally developed by Willett *et al.*[127] Assessed by energy-adjusted correlations, mean or median differences, and exact level of agreement. Good correlation of intakes estimated by FFQ with biomarkers Overestimation of vitamin C and carotenes by FFQ relative to 7 d diet diary	No details‡
HTT[71]	Cross-sectional	Adults (*n* 18 000)	9 (Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Ukraine)	FFQ†	No details‡	No details‡
Hupkens *et al.*[72]	Cross-sectional	Adults/women (*n* 849)	3 (Belgium, Netherlands, Germany)	FFQ† (based on Netherlands Cohort Study FFQ)	Validated using diet records[128] Assessed by crude correlations, mean or median differences FFQ can rank individuals according to food groups and nutrient intake	No details‡
I.Family Project[50,73,74]	Prospective cohort study (successor of IDEFICS study)	Adults/parents ($n > 7000$)	8 (Belgium, Cyprus, Estonia, Germany Hungary, Italy, Spain, Sweden)	Diet questionnaire as part of the parent questionnaire Online 24-HDR (SACANA)	Similar to validated instruments used in the IDEFICS project	No details‡
IHBS[75]	Cross-national	Adults (*n* 17 246)	17 (Austria, Denmark, England, Finland, France, Germany, Greece, Iceland, Ireland, Netherlands, Norway, Poland, Portugal, Scotland, Spain, Sweden, Switzerland)	FFQ†	No details‡	No details‡

Downloaded from http://www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http://www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

Table 2 *Continued*

Study	Design	Population	Countries	Instrument(s)	Validation	Reproducibility
IMMIDIET[76]	Cross-sectional	Adults (*n* 802)	3 (Italy, Belgium, England)	EPIC-Italian FFQ† EPIC-UK FFQ† Specifically developed Belgian FFQ	Based on EPIC UK and Italian FFQ which have been validated using weighed diet records[141], biomarkers[141,143] and 24-HDR[143]. Belgian FFQ validated using 7 d diet records and 24-HDR[39,129] Assessed by energy-adjusted correlations, de-attenuated correlation coefficients, and mean or median differences Generally good correlation between FFQ and diet records	No details‡
Kolarzyk *et al.*[48]	Cross-sectional	Adults/students (*n* 1517)	4 (Poland, Belarus, Russia, Lithuania)	FFQ†	Validated and recommended by the National Food and Nutrition Institute in Warsaw, Poland[49]	No details‡
LiVicordia[77]	Cross-sectional	Adults/men (*n* 150)	2 (Lithuania, Sweden)	24-HDR	No details‡	No details‡
LLH[71]	Cross-sectional	Adults (*n* 18 428)	8 (Armenia, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Ukraine)	FFQ	No details‡	No details‡
MEDIS[78]	Cross-sectional	Adults/elderly (*n* 1190)	2 (Cyprus, Greece)	FFQ	Validated using diet records[138] Assessed by crude correlations, mean or median differences and exact level of agreement Moderate agreement for fruit and low agreement for vegetables	Interval: 10–30 d[138] Reproducibility of FFQ is fair
MGSD[79]	Cross-sectional	Adults (*n* 4254) Non-diabetics (*n* 1833)	6 (Greece, Italy, Algeria, Bulgaria, Egypt, Yugoslavia (only diabetics in Yugoslavia))	Dietary history method using questionnaire†	Validated using diet records[79]	No details‡
NORBAGREEN[41,80]	Cross-sectional	Adults and adolescents (*n* 8397)	8 (Norway, Denmark, Sweden, Finland, Latvia, Lithuania, Estonia, Iceland)	FFQ†	Validated using 3 d diet records in Finland and four 24-HDR in Lithuania[80] Assessed by crude correlations, mean or median differences, and exact level of agreement FFQ is valid to rank individuals according to F&V intake	Interval: 6–8 months[80] Provides reproducible estimates of food group intake
North/South Food Consumption Survey[45,81]	Cross-sectional	Adults (*n* 1379)	2 (Northern Ireland, Republic of Ireland)	7 d record	No details‡	No details‡
O'Neill *et al.*[82]	Cross-sectional	Adults (*n* 400)	5 (UK, Republic of Ireland, Spain, France, Netherlands)	FFQ†	No details‡	No details‡
Parfitt *et al.*[83]	Cross-sectional	Adults/students (*n* 48)	2 (England, Italy)	5–7 d record	No details‡	No details‡
PRIME[84]	Cohort	Adults (*n* 8087 used for present study)	2 (Northern Ireland, France)	FFQ	Not validated against another dietary assessment method. A correlation analysis between the frequency of fruit and/or vegetable intake and plasma vitamins was performed in 100 men to assess the ability of the questionnaire to discriminate large *v.* small consumers of fruits and vegetables[84]	No details‡

Downloaded from http://www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http://www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

Table 2 *Continued*

Study	Design	Population	Countries	Instrument(s)	Validation	Reproducibility
PRO GREENS[85]	Cross-sectional	Adults/parents	10 (Austria, Belgium, Denmark, Iceland, Netherlands, Norway, Portugal, Spain, Sweden, Finland)	A pre-coded 24-HDR†, FFQ†	No details‡	No details‡
Pro-Children study[42,86,87]	Cross-sectional	Adults/parents Number NR	9 (Austria, Belgium, Denmark, Iceland, Netherlands, Norway Portugal, Spain, Sweden)	A pre-coded 24-HDR†, FFQ†	Validated using 7 d diet records (1 d weighed record and 6 d record using household measures)[130] Assessed by crude correlations, mean or median differences, and exact level of agreement FFQ valid for ranking adults according to usual intake	No details‡
Rylander *et al.*[88]	Cross-sectional	Adults/women (*n* 6785)	2 (Sweden, Switzerland)	FFQ	No details‡	No details‡
SENECA[43,44,89,90]	Mixed design (longitudinal and cross-sectional)	Adults/elderly (*n*≈2600) 70–75 years	12 (Belgium, Denmark, France, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Spain, Switzerland)	Modified dietary history method comprising a 3 d estimated record and meal-based frequency checklist	Validated against a 3 d weighed record[89] **No validation data for F&V**	No details‡
Seven Countries Study[4,91,92]	Cross-sectional	Adults/men (*n* 12 763 (enrolled)) 40–59 years (at enrolment)	7 (Netherlands, Finland, Yugoslavia, Japan, Italy, Greece, USA)	Cross-check dietary history method European cohorts (*n* 14) used 7 d records at baseline	No details‡	Interval: 3 and 12 months after the initial surveys[104] Small differences in reproducibility estimates
Terry *et al.*[93]	Case–control	Adults/controls (*n* 2486) 20–82 years	6 (Germany, France, Canada, Sweden, Australia, USA)	FFQ	No details‡	No details‡
Tessier *et al.*[94]	Cross-sectional	Adults/women (*n* 123 mother/daughter pairs) 50–91 years 22–60 years	2 (Malta, Italy)	Open-ended qualitative questionnaire†	No details‡	No details‡
ToyBox[95–106]	Intervention multifactorial study	Adults/parents Number NR Age range NR	6 (Belgium, Bulgaria, Germany, Greece, Poland, Spain)	Primary caregiver's FFQ (PCQ)†	No details‡	Test–retest reliability of the PCQ was assessed after 2-week interval[112] **No data for F&V**
Van Diepen *et al.*[107]	Cross-sectional	Adults/students (*n* 185) Age range NR	2 (Greece, Netherlands)	2 × consecutive 24-HDR	No details‡	No details‡
WHO-MONICA EC/MONICA Project optional nutrition study[46,108,123]	Cross-sectional	Adults (*n* 7226) 45–64 years	9 (Northern Ireland, UK (Cardiff), Denmark, Finland, Belgium, Germany, France, Italy, Spain)	3 d record and 7 d record One centre used 3 × 24-HDR	No details‡	No details‡

Downloaded from http://www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http://www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

Table 2 *Continued*

Study	Design	Population	Countries	Instrument(s)	Validation	Reproducibility
Adolescents						
Gerrits *et al.*[109]	Cross-sectional	Adolescents (*n* 537) 14–19 years	3 (Netherlands, Hungary, USA)	FFQ	No details‡	No details‡
HBSC[31,110]	Cross-sectional	Adolescents (*n* 209 320) 11-, 13- and 15-year-olds	37 (England, Norway, Macedonia, Iceland, Netherlands, Portugal, Wales, Italy, Sweden, Latvia, Switzerland, Denmark, Estonia, Scotland, Slovenia, Ukraine, Belgium, Finland, Greece, Croatia, Hungary, Lithuania, Poland, Germany, Greenland, Russia, Armenia, Austria, Belgium, Spain, France, Romania, Turkey, Czech Republic, Ireland, Luxembourg, Slovakia)	FFQ†	Validated using 24 h food behaviour checklist and a 7 d food diary[132] Assessed by crude correlations, energy-adjusted correlations, and mean or median differences in F&V consumption Good agreement but overestimation of intakes by FFQ *v.* 7 d diary	Interval: 7–15 d[123] Provides reproducible estimates of food group intake
HELENA[32–36,50,111,112]	Cross-sectional	Adolescents (*n* 3000) 13–17 years	9 (Greece, Germany, Belgium, France, Hungary, Italy, Sweden, Austria, Spain) 8 countries included for 24-HDR (as above, except Hungary) Only Belgium tested the online FFQ 5 (Austria, Belgium, Greece, Sweden, Germany) pilot-tested the online FFQ	24-HDR HELENA-DIAT (Dietary Assessment Tool)† Online FFQ	YANA-C validated using food records and 24 h dietary recall interviews[35] Assessed by crude correlations and median or mean differences Good agreement between intakes assessed by 24-HDR administered by self-report and interview Validated using four computerised 24-HDR[35,121] Overestimation for vegetables	Interval: 1–2 weeks HELENA FFQ has adequate reliability
Larsson *et al.*[113]	Cross-sectional	Adolescents (*n* 2041) Age range NR	2 (Sweden, Norway)	FFQ†	No details‡	No details‡
Szczepanska *et al.*[114]	Cross-sectional	Adolescents (*n* 404) Age range NR	2 (Poland, Czech Republic)	FFQ†	No details‡	No details‡
TEMPEST[115]	Cross-sectional	Adolescents (*n* 2764) 12–17 years	4 (Netherlands, Poland, UK, Portugal)	FFQ†	No details‡	No details‡
I.Family Project[50,73,74]	Prospective cohort study (successor of IDEFICS study)	Adolescents (*n* >9000 children of IDEFICs study and their siblings) 12–17 years	8 (Belgium, Cyprus, Estonia, Germany Hungary, Italy, Spain, Sweden)	Diet questionnaire as part of the parent questionnaire Online 24-HDR (SACANA)	Instruments are similar to validated instruments used in the IDEFICS project	No details‡
Children						
Antova *et al.*[116]	Cross-sectional	Children (*n* 20 271) 7–11 years	6 (Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia)	FFQ†	No details‡	No details‡

Downloaded from http://www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http://www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

Table 2 *Continued*

Study	Design	Population	Countries	Instrument(s)	Validation	Reproducibility
ENERGY[27]	Cross-sectional	Children (*n* 7234) 10–12 years	7 (Belgium, Greece, Hungary, Netherlands, Norway, Slovenia, Spain)	Questionnaire with FFQ and 24-HDR†	No details‡	The reliability and content validity of the child questionnaires were tested separately in all participating countries[143] Reliability tested using a test–retest design was used by comparing data from two completions of the questionnaire conducted 1 week apart[130] **No reliability data for F&V**
EYHS[30,117]	Cross-sectional	Children ($n \approx 4000$) 9 and 15 years	4 (Denmark, Portugal, Estonia, Norway) (sourced study involves only Sweden)	24-HDR, qualitative food record	Children's ability to recall what they consumed during a 24 h period was compared with observational data collected during the same period[144] **Not conducted among European population**	No details‡
IDEFICS[37,38,118,119]	Prospective cohort study with an embedded intervention	Children (*n* 16 224) 2–9 years	8 (Belgium, Cyprus, Estonia, Germany Hungary, Italy, Spain, Sweden)	CEHQ-FFQ† SACINA 24-HDR†[50]	Validity was assessed using biomarkers[140] and 24-HDR[38]. **No biomarker validation data for F&V** Assessed against 24-HDR by crude correlations, de-attenuated correlation coefficients, mean or median differences, and exact level of agreement Association between FFQ and 24-HDR varied by food group and age. Low agreement of FFQ with 24-HDR High relative validity between FFQ and 24-HDR. FFQ can reliably estimate food group intake among Spanish children SACINA is based on the YANA-C instrument validated as part of the HELENA study[35,135]. SACINA was validated using the doubly labelled water technique[134]. **No validation data on F&V**	Interval: 0–354 d (no fixed time period)[145] CEHQ-FFQ provides reproducible estimates of food group intake
I.Family Project[50,73,74]	Prospective cohort study (successor of IDEFICS study)	Children ($n > 9000$ children of IDEFICS study and their siblings) 2–11 years	8 (Belgium, Cyprus, Estonia, Germany Hungary, Italy, Spain, Sweden)	Diet Questionnaire (FFQ) as part of the children's questionnaire Online 24-HDR (SACANA)	Instruments are similar to validated instruments used as part of the IDEFICS project	No details‡
ISAAC Phase II[40,120]	Cross-sectional	Children ($n \approx 63\,000$ including international countries) 8–12 years	15 (Albania, France, Estonia, Germany, Georgia, Greece, Iceland, Italy, Latvia, Netherlands, Norway, Spain, Sweden, Turkey, UK)	FFQ†	No details‡	No details‡

Downloaded from http://www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http://www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

Table 2 *Continued*

Study	Design	Population	Countries	Instrument(s)	Validation	Reproducibility
PRO GREENS[85]	Cross-sectional	Children (*n* 8159) 11 years	10 (Austria, Belgium, Denmark, Iceland, Netherlands, Norway, Portugal, Spain, Sweden, Finland)	A pre-coded 24-HDR†, FFQ†	Validity of 24-HDR and FFQ was tested in 4 countries (Denmark, Iceland, Norway, Portugal) using a 1 d weighed food record and 7 d food records Assessed by crude correlations, mean or median differences, and exact level of agreement FFQ: Moderately good ranking of F&V food groups in 4 countries 24-HDR: Valid estimates for fruit in 3 countries (exception Portugal) Valid estimates for vegetables in 2 countries (exception Iceland and Norway)	Assessed in 6 countries (Belgium, Denmark, Iceland, Norway, Portugal, Spain) Interval: 7–12 d[42] Good reproducibility for FFQ Test–retest reliability carried out in 5 countries (Norway, Spain, Denmark, Portugal, Belgium) with a 1-week interval[136] **No information on F&V intake**
Pro-Children study[42,86,87]	Cross-sectional	Children (*n* 15 404) 11 years	9 (Austria, Belgium, Denmark, Iceland, Netherlands, Norway Portugal, Spain, Sweden)	A pre-coded 24-HDR†, FFQ†	As per PRO-GREENS[42,136]	As per PRO-GREENS[42,136]
ToyBox[95–106]	Intervention multifactorial study	Children (*n* 5472) 3·5–5·5 years	6 (Belgium, Bulgaria, Germany, Greece, Poland, Spain)	Children's FFQ†	Validated using estimated 3 d diet records[137] Assessed by crude correlations, de-attenuated correlation coefficients, mean or median differences, and exact level of agreement Moderate relative validity between FFQ and diet records	Interval: at least 5 weeks[137] FFQ provides reproducible estimates of food group intake

CNSHS, Cross National Student Health Survey; ECRHS, European Community Respiratory Health Survey; EHBS, European Health and Behaviour Survey; ENERGY, EuropeaN Energy balance Research to prevent excessive weight Gain among Youth; EPIC, European Prospective Investigation into Cancer and Nutrition; ESCAREL, European Study in Non Carious Cervical Lesions; HAPIEE, Health, Alcohol and Psychosocial factors in Eastern Europe; HTT, Health in Times of Transition; IHBS, International Health and Behaviour Survey; LLH, Living Conditions, Lifestyles and Health; MEDIS, MEDiterranean Islands Study; MGSD, Mediterranean Group for the Study of Diabetes; SENECA, Survey in Europe on Nutrition and the Elderly; a Concerted Action; MONICA, Multinational MONItoring of trends and determinants in CArdiovascular disease; HBSC, Health Behaviour in School-aged Children; HELENA, Healthy Lifestyle in Europe by Nutrition in Adolescence; TEMPEST, 'Temptations to Eat Moderated by Personal and Environmental Self-regulatory Tools'; EYHS, European Youth Heart Study; IDEFICS, Identification and prevention of Dietary- and lifestyle-induced health EFfects In Children and infantS; ISAAC, International Study of Asthma and Allergies in Childhood; NR, not reported; 24-HDR, 24 h recall; PCQ, Primary Caregiver's Questionnaire; F&V, fruit and vegetables; YANA-C, Young Adolescents' Nutrition Assessment on Computer; CEHQ, Children's Eating Habits Questionnaire.

*Funded by the Wellcome Trust programme grant entitled 'Determinants of Cardiovascular Diseases in Eastern Europe: A multi-centre cohort study' (reference number 064947/Z/01/Z) and developed by Martin Bobak, Anne Peasey, Hynek Pikhart (UCL), Ruzena Kubinova, Lubomíra Milla Novosibirsk, Sofia Malyutina, Oksana Bragina (Prague), Andrzej Pajak, Aleksandra Gilis-Januszewska (Krakow).

†Original instrument obtained for review.

‡Validation or reproducibility of the instrument was not reported in the article and no reference to validation or reproducibility studies were provided.

methods, in the interest of comprehensiveness, details on all the identified methods are provided.

Instruments which met the two selection criteria for which validation data on F&V intake were available are summarized in Table 3. Of those for use among adults, F&V intakes assessed by EPIC-SOFT were described by authors as having weak to moderate correlation with biomarkers[63]. The Food4Me FFQ was reported to demonstrate moderate agreement with a 4 d weighed food record[53] and good agreement with the EPIC-Norfolk FFQ[52]. While the ToyBox Primary Caregiver's Questionnaire was tested for reliability there were no data available for F&V. Similarly, the ENERGY parent questionnaire was tested for reliability but data were unpublished. The Seven Countries Study dietary history instrument was not validated but reproducible[131]. HELENA-DIAT, administered by self-report, was reported to have good agreement with intakes when administered by interview[35]. The HELENA-FFQ was found to have adequate reliability[36]. The HBSC FFQ was found to be reproducible and reported to have good agreement with a 7 d food diary[132].

The IDEFICS FFQ was compared with two 24-HDR but had low agreement with 24-HDR according to the authors, and agreement varied by food group and age of child in a population across eight survey sites[38]. However, the instrument had good agreement with 24-HDR in a sample of Spanish children[135] and has been demonstrated to be reproducible[145]. The Pro-Children instrument, when compared with 7 d[130] and 1 d[42] diet records, was reported to have moderate to good validity for ranking individuals according to usual intake and was reproducible[42]. The ToyBox study instrument was shown to be reproducible and was reported to have moderate relative validity when compared with 3 d diet records[137].

FFQ

Range of items and definitions

Characteristics of the identified FFQ are summarised in Table 4. FFQ were used to assess dietary intake, identify determinants of dietary intake, or test diet–disease associations and identify disease risk factors. The number of food items listed on these FFQ ranged between sixty-six and 322, with the number of items relating to fruit and vegetables ranging from one item[27,60] to ninety-five items[82]. Several FFQ used non-itemised terms such as 'fruit', 'vegetables', 'fresh fruit', 'raw vegetables' and 'cooked vegetables'[37,42,48,56,58,64,66,67,69,75,84,100,109,110,114–116,120], while others listed individual fruits and vegetables[30,39,41,52,53,82,150]. FFQ could be classed as having low (<5 items relating to fruit or vegetables) or high (>5 items relating to fruit or vegetables) comprehensiveness based on the cut-off used by Cook *et al.*[151]. Thirteen FFQ were classed as having low comprehensiveness for F&V, including the ENERGY and HBSC questionnaires[27,31,48,56,57,64,66,71,75,114–116,120].

Some FFQ further subdivided F&V into 'raw/fresh', 'cooked' or 'tinned', each with separate items listed underneath[150]. The NORBAGREEN FFQ[41] and the FFQ used by Larsson *et al.*[113] assessed the consumption of individual fruits and vegetables, but also included a cross-check question on the total consumption of vegetables and fruits. The NORBAGREEN FFQ assessed consumption within different contexts and using different cooking styles; for example, asking participants to report the frequency of consumption of 'cooked, canned or steamed vegetables' and of 'dried fruit or berries'.

Where individual F&V items were listed, FFQ also varied in terms of whether pulses[38,82] or potatoes[58,109] were included under 'vegetables'. Some FFQ listed potatoes as 'cooked vegetables'[38,67], 'white-yellowish vegetables'[82] or specified 'vegetables (potatoes excluded)'[71,113]. Many FFQ listed separate potato items or 'potatoes' and 'legumes/pulses' as separate group headings with their own items listed below[30,36,38,39,48,52,53,66,100,113,150]. With some exceptions[52,53,86,104], if an FFQ listed fruit or vegetable juice it did not always specify 100 % fruit or vegetable juice[27,86,100]. Therefore, participants could interpret this as including fruit squash and dilutions.

Mode and structure

All FFQ were paper-based and self-administered with some exceptions in which the FFQ was web-based[51], administered via face-to-face interview[93,147] or by computer-assisted telephone interview[41]. Most of the identified FFQ used pre-coded frequency categories. The majority provided a single frequency scale with typically five or six categories extending from 'never', 'less than once a month' or 'less than once a week' to 'every day', 'more than once a day', 'more than *X* times per day' or 'several times a day'[31,40,48,104,113,114,122], although the ENERGY FFQ asked participants to select from seven frequency options per week or six frequency options per day. The ESCAREL (European Study in Non Carious Cervical Lesions) FFQ provided a two-step frequency scale: participants first specified whether they consumed fruit juice 'often' and then provided a frequency from 'more than three times per week' to 'less than once per week'.

Time period

Most FFQ specified the time period to which consumption frequency referred, generally the previous 12 months. However, other time periods were used, including the previous 3–4 months[82], 3 months[70], 1 month[48,52–54] and 1 week[27,66,71,110,139], or consumption on an average day[115]. The remaining FFQ did not provide a specific time period and participants were directed to report usual or habitual intake. Some FFQ assessed consumption of certain F&V by season[65,116].

Portion size estimation

The majority of FFQ were semi-quantitative and assessed both frequency and amount; in most cases, assessing portion

Downloaded from http:/www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http:/www.cambridge.org/core/terms.
http://dx.doi.org/10.1017/S1368980016002366

Table 3 Summary of the selected instruments which were validated (*n* 8) for assessment of fruit and vegetables

Study/instrument	Design	Age group	Countries	Mode	Portion estimation
Adults					
EPIC[18,28,29,61–63] EPIC-SOFT 24-HDR	Cohort	30–70 years	10 (Italy, Spain, Netherlands, Germany, Sweden (Malmo)/Sweden(Umea), Denmark, France, Greece, Norway, England)	Face-to-face interview Computerised	X
Food4Me[51–53] Web-based FFQ	Randomised controlled trial	17–79 years	7 (Ireland, Netherlands, Spain, Greece, UK, Poland, Germany)	Self-admin.	X
Adolescents					
HBSC[31,110] FFQ	Cross-sectional	11-, 13- and 15-year-olds	37 (England, Norway, Macedonia, Iceland, Netherlands, Portugal, Wales, Italy, Sweden, Latvia, Switzerland, Denmark, Estonia, Scotland, Slovenia, Ukraine, Belgium, Finland, Greece, Croatia, Hungary, Lithuania, Poland, Germany, Greenland, Russia, Armenia, Austria, Belgium, Spain, France, Romania, Turkey, Czech Republic, Ireland, Luxembourg, Slovakia)	Self-admin.	
HELENA[32–36,50,111,112] 24-HDR HELENA-DIAT	Cross-sectional	13–17 years	8 (Greece, Germany, Belgium, France, Italy, Sweden, Austria, Spain)	Self-admin. Computerised	X
HELENA[32–36,50,111,112] Online FFQ		13–17 years	5 (Austria, Belgium, Greece, Sweden, Germany)	Self-admin.	X
Children					
IDEFICS[37,118,119] CEHQ-FFQ*	Prospective cohort study with an embedded intervention	2–9 years	8 (Belgium, Cyprus, Estonia, Germany Hungary, Italy, Spain, Sweden)	Self-admin. (parents)	
Pro-Children study[42,86,87] A pre-coded 24-HDR*, FFQ*	Cross-sectional	11 years	9 (Austria, Belgium, Denmark, Iceland, Netherlands, Norway Portugal, Spain, Sweden)	Self-admin.	X
ToyBox[95–106] Children's FFQ*	Intervention multifactorial study	3·5–5·5 years	6 (Belgium, Bulgaria, Germany, Greece, Poland, Spain)	Self-admin.	X

EPIC, European Prospective Investigation into Cancer and Nutrition; 24-HDR, 24 h recall; HBSC, Health Behaviour in School-aged Children; HELENA, Healthy Lifestyle in Europe by Nutrition in Adolescence; IDEFICS, Identification and prevention of Dietary- and lifestyle-induced health EFfects In Children and infants; CEHQ, Children's Eating Habits Questionnaire; self-admin., self-administered.
*Original instrument obtained for review.

Downloaded from http://www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http://www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

Downloaded from http://www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http://www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

Table 4 Summary of FFQ: instrument purpose and characteristics

Study	Type/no. of items	Purpose	Population	F&V items & classification	Reference period	Mode	Categories	Portion estimation
Adults								
Baldini *et al.*[54]*	Semi-quantitative Sixty-one-item FFQ	Assess dietary habits Assess influence of lifestyle on energy balance and BMI	Adults/students Age range NR	Exact classification unknown† Used Willett FFQ[127]	Previous month	Self-admin.	Detailed record of food consumption, starting from breakfast and ending at bedtime 9 categories, ranging from 'never' to '6 or more times per day'	Yes Assessed separately Pictures of standard meal/food sizes Used natural units if possible A full description of usual serving size was provided for each item
Behanova *et al.*[56]*	Semi-quantitative General questionnaire	Determine prevalence of health-risk behaviours	Adults 19–64 years	Non-itemised Two items: 'Portions of vegetables' 'Portions of fruits' (including dried fruit, fruit juice)	NR	Self-admin.	Open-ended Subject to report a number of portions	Yes Assessed in-line Examples given for 1 portion, e.g. handful of dried fruit, heaped tablespoon of carrots
CNSHS[57,58]	Non-quantitative General questionnaire	Test association between food patterns and living arrangements[57] Test association between diet and stress/depressive symptoms[58]	Adults/students Age range NR	Four items: 'Fresh fruits' 'Raw vegetables' 'Cooked vegetables' 'Salads'	NR	Self-admin.	5 categories, ranging from 'several times a day' to '1–4 times a month' and 'never'	No
ENERGY[27]*	Semi-quantitative General questionnaire	Determine prevalence of EBRB Identify personal, family and school environmental correlates of EBRB	Adults/caregivers Age range NR	One item: Fruit juices. 'When we say fruit juices we mean the packed fruit juice and freshly blended juice at home (100 % fruit juice)' Examples provided	Previous week Usual consumption on a day on which fruit juices are drunk	Self-admin.	7 categories per week 6 categories per day	Yes Assessed in-line Subject can select number of glasses/small cartons (250 ml) and regular cartons (330 ml) drank on a day of consumption
EHBS[60]	Refer to IHBS	Test association between health locus of control and health behaviour	Refer to IHBS	One item: 'Fruit consumption'	Refer to IHBS	Refer to IHBS	Refer to IHBS	Refer to IHBS
ESCAREL[64]*	Non-quantitative Five-item FFQ within a general questionnaire	Assess the prevalence of tooth wear on buccal/facial and lingual/palatal tooth surfaces Identify related risk factors (i.e. fresh fruit and juice intake)	Adults 18–35 years	Two items: 'Fresh fruit, e.g. lemon, orange, apple, pear, grapes, mango, etc.' 'Fruit and vegetable juice, e.g. orange, apple, grape, pineapple, carrot, multivitamin, etc.'	NR	Self-admin.	4 categories: 'often', 'rarely', 'never' and 'don't know' For items ranked as 'often' a choice of 5 categories, ranging from 'more than 3 times per week' to 'less than once per week'	No
Esteve *et al.*[65]	Semi-quantitative Dietary questionnaire	Test association between diet and cancers of the larynx and hypopharynx	Adults Age range NR	Exact classification unknown† Seasonality of F&V assessed	12 months	Face-to-face interview	Structured by meals, i.e. breakfast, lunch, dinner, as well as early morning, mid-morning, mid-afternoon and late evening snacks	Yes Assessed separately Usual portion size estimated during interview. Method NR
Finbalt Health Monitor[66]*	Non-quantitative Seventeen-item FFQ within general questionnaire	Assess gender differences in F&V consumption	Adults 20–64 years	Four items: 'Fresh vegetables' 'Other vegetables' 'Fresh fruit/berries' 'Other fruit/berries' Potatoes assessed separately	Previous week	Self-admin.	4 categories: 'never', '1–2 days', '3–5 days' and '6–7 days'	No

Downloaded from http://www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http://www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

Table 4 *Continued*

Study	Type/no. of items	Purpose	Population	F&V items & classification	Reference period	Mode	Categories	Portion estimation
Food4Me[51–53]‡	Semi-quantitative Web-based 157-item FFQ	Determine impact of personalised dietary advice on eating patterns and health outcomes	Adults 18–79 years		Previous month	Self-admin.	9 categories, ranging from 'never or less than once a month' to '5–6 times per day' and '>6 times per day'	Yes 3 photographs representing small, medium and large portions Participants could select one of the following options: very small, small, small/medium, medium, medium/large, large or very large, which were linked electronically to portion sizes (in grams)
Galanti *et al.*[69]	Semi-quantitative Sixty-item FFQ (Norway) Fifty-six-item FFQ (Sweden)	Test association between diet and papillary and follicular thyroid carcinoma	Adults 18–60+ years	Exact classification unknown† Six items: 'All vegetables' 'Vegetables, excluding cruciferous' 'Cruciferous vegetables' 'All fruit (piece)' 'Apple' 'Citrus fruit'	NR	Self-admin.	For foods which traditionally are consumed more often and for all beverages, average number of servings was requested, per day, week or month Less frequently consumed foods: 6 pre-coded frequencies, ranging from 'never' to 'once a day or more often'	Yes Assessed in-line Asked to specify number of servings
HAPIEE[70]*	Semi-quantitative Czech = 136-item FFQ Russian = 147-item FFQ Polish = 148-item FFQ	Test association between socio-economic indicators and diet[147]	Adults 45–69 years	As per generic FFQ (note: number of items differs slightly for each local adaption) Fifty-three items: Twenty-one items under 'Fresh fruit' 'Tinned or bottled fruit' Thirty-one items under 'Vegetables' (Pulses included) 1 fruit juice Potatoes assessed separately	Previous 3 months	Interview (Russia & Poland) Self-admin. (Czech Republic)	9 categories, ranging from 'never' to 'six or more times per day' Open-ended section where subjects could add any further foods not listed	Yes Assessed in-line A country-specific portion size for each food was specified Participants were asked how often, on average, they had consumed a 'medium serving' of the items – defined as about 100 g or 50 g depending on the food in question
HTT[71]*	Non-quantitative Ten-item FFQ within a general questionnaire	Identify factors associated with low consumption of F&V	Adults Age range NR	Two items: 'Fresh fruit' 'Fresh vegetables (except for potatoes)'	Previous week	Face-to-face interview	4 categories, ranging from 'daily/almost daily' to 'less than once a week'	No
Hupkens *et al.*[72]	Semi-quantitative 150-item FFQ used for NCS	Test association between social class factors and fat and fibre consumption	Adults 55–69 years	Twenty-eight items: Thirteen boiled veg items Five raw veg items Seven fruit items Three juice items Potatoes assessed separately Vegetable seasonality assessed	12 months	Self-admin.	6 categories (veg), ranging from 'never' to '3 or 7 times per week' 6 categories (fruit), ranging from 'never' to '6 or 7 times per week' Open-ended section for foods not on the FFQ	NR
I.Family Project[50]	Non-quantitative Sixty-item FFQ	Assess determinants of eating behaviour	Adults/parents No age range determined	Nine items: Four veg items (including legumes and potatoes) Two fruit items (fresh with or without sugar) One fruit juice item Nuts and dried fruits separately (two items) under 'snacks'	Typical week over the previous month	Self-admin.	7 categories, ranging from 'never/less than once a week' to '4 or more times per day'	No

Downloaded from http://www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http://www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

Table 4 *Continued*

Study	Type/no. of items	Purpose	Population	F&V items & classification	Reference period	Mode	Categories	Portion estimation
IHBS[75]*	Non-quantitative Two-item FFQ within a general questionnaire	Test association between life satisfaction and health behaviours	Adults 17–30 years	One item: 'Fruit'	NR	Self-admin.	5 categories, ranging from 'never' to 'at least once every day'	No
IMMIDIET[39,76]	Semi-quantitative 322-item EPIC-Italy FFQ (as above) EPIC-UK FFQ (as above)	Identify determinants (diet, genetic) of risk of myocardial infarction[39] Determine role of dietary patterns in plasma and red blood cell fatty acids variation[76]	Adults 26–65 years	Sixty-three items: Twenty-one cooked veg items Ten raw veg items Thirty-two fruit items (including fresh, tinned, dried) Potatoes and legumes assessed separately	12 months	Face-to-face interview Self-admin. in validity study[40]	9 categories, ranging from 'never/rarely', '1–3 days/month' to '1, 2, 3, 4, 5, 6, 7 days per week'	Yes Assessed separately Recorded as absolute weights or as household measurements Photo book to estimate small, average and large portions for spreads, bread spreads, and milk in coffee and tea
LLH[71]*	Non-quantitative Nine-item FFQ within a general questionnaire	Identify factors associated with low consumption of F&V	Adults Age range NR	Two items: 'Fruit' 'Vegetables (except for potatoes'	Previous week	Face-to-face interview	4 categories, ranging from 'extremely seldom' to 'daily'	No
NORBAGREEN[41,80]*	Non-quantitative Fifty-six-item FFQ	Assess the frequency of consumption of vegetables, potatoes, fruit, bread and fish	Adults and adolescents 15–74 years	Thirty-nine items: Questions on global 'Vegetables and roots' and 'Fruits and berries' consumption (including pulses) Nineteen veg items Fourteen fruit items Four potato items Potatoes assessed separately	12 months	Using CATI in the Nordic countries and PAPI in the Baltic countries	Times per month, ranged from '<1 or not at all' to '3' Times per week, ranged from '1' to '6' Times per day, ranged from '1' to '4 or more'	No
MGSD[79]*	Semi-quantitative Dietary history questionnaire with seventy-eight items	Compare the nutritional habits among six Mediterranean countries and with official recommendations	Adults 35–60 years	Eleven items: Three 'Cooked veg' non-itemised questions, each with different veg group One 'Raw veg' item Two itemised veg (onions, garlic) Two 'Cooked legumes' items One 'Fruit' item One 'Juice' item One 'Dried fruit' item Potatoes assessed separately	NR	Face-to-face interview	Enter number per day or per week for pre-coded items Open-ended section structured by seven meals, whereby subject enters the time, description, quantity, and whether food eaten at home or in a restaurant	Yes Assessed in-line 15 g or about 1 tablespoon 100 g or 1 cup (raw veg) 200 g or 1 cup (cooked veg A) 100 g or 1 cup (cooked veg B) 200 g or 1 cup (cooked veg C) 150 g (fruit) 200 g or 1 glass (juice) Assessed separately Household measures
O'Neill *et al.*[82]*	Semi-quantitative 107-item FFQ	Determine and compare carotenoid intakes across European countries	Adults 25 ± 45 years	Ninety-five items: Twenty-eight green veg items (including pulses) Seventeen red-orange vegetable items Seventeen white-yellowish coloured veg items (including potatoes) Twenty-seven individual fruit items Six F&V relevant items under 'Other products' (mainly tomato products and soups and orange juice)	Past 3–4 months	Self-admin.	If high frequency, range from 1 to 7 per week If low consumption frequency, 4 categories ranging from 'never' to 'once per fortnight'	Yes Assessed separately Asked to quantify intake for each food item by tablespoons for vegetables and by large, small or medium in terms for fruit
PRIME[84]	Non-quantitative No. of items NR	Assess relationship between F&V intake and CVD	Adults/men 50–59 years	Exact classification unknown† 'Citrus fruit', 'Other fruit', 'Raw vegetables' 'Baked vegetables'	NR	Self-admin.	7 categories, ranging from 'never' to 'more than once per day' (subject reports number per day)	Assessed in-line Frequency of consumption of a 'standard portion'

Downloaded from http://www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http://www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

Table 4 *Continued*

Study	Type/no. of items	Purpose	Population	F&V items & classification	Reference period	Mode	Categories	Portion estimation
Finnish and Russian Karelia study[146]* (2002 survey)	Non-quantitative Forty-three-item FFQ (FINRISK) and two-item FFQ (Pitkaranta town) within a general questionnaire	Determine impact of socio-economic differences on consumption of F&V and berries	Adults 25–64 years	Finnish FFQ: Nine items: Six 'Vegetables' items (including pulses, potatoes) Three 'Fruits/berries' items Russian FFQ: Six items: Four 'Vegetables' items (including pulses, potatoes) Two 'Fruits and berries' items	12 months	Self-admin.	6 categories, ranging from 'less than once a month' to 'once a day or more often'	No
Rylander *et al.*[88]	Non-quantitative Ninety-item FFQ	Test association of dietary habits and smoking status	Adults 35–65 years	Exact classification unknown†	12 months	Self-admin.	10 categories, ranging from 'never' to 'six or more times per day'	No
ToyBox Caregiver's Questionnaire[95–106]*	Semi-quantitative. Five-item FFQ (drinking behaviour) and fourteen-item FFQ (snacking behaviour) within a general questionnaire	Measure the effectiveness of an intervention to prevent obesity	Adults/caregivers Age range NR	Three items: Drinking behaviour: Examples provided. 'Fruit juice, home-made, freshly squeezed' Snacking behaviour: 'Fresh fruits' 'Vegetables'	12 months	Self-admin.	7 categories, ranging from '1–3 days per month' to 'every day'	Yes Assessed in-line Portion size specified for fruit juice as beaker = 225 ml, 1 small plastic bottle = 500 ml, 1 carton = 1 litre Aided by a photo book
MEDIS[78]	Non-quantitative No. of items NR	Test association between energy-generating nutrients and obesity	Adults/elderly 65–80+ years	Exact classification unknown† 'Fruits', 'Vegetables', 'Greens and salads' Potatoes and legumes assessed separately	NR	NR	Frequency assessed on a daily, weekly or monthly basis	No
Terry *et al.*[93]	Semi-quantitative Dietary questionnaire No. of items NR	Test association between diet and brain tumour risk	Adults 20–82 years	Exact classification unknown†	NR	Face-to face interview	Exact classification unknown†	Yes Assessed separately Abstract food models or photographs used to aid portion size estimation
Pro-Children[86]*	Non-quantitative Six-item FFQ within a general questionnaire	Assess F&V consumption Identify determinants of F&V consumption patterns	Adults/parents Age range NR	Six items: 'Fresh fruit' 'Salad or grated vegetables' 'Raw vegetables' 'Cooked vegetables' '100 % fruit juice' Potatoes assessed separately	NR	Self-admin.	8 categories, ranging from 'never' to 'every day, more than twice a day'	No
Kolarzyk *et al.*[48]*	Non-quantitative Thirty-nine-item FFQ	Assess diet and the prevalence of underweight, overweight and obesity	Adults/students Age range NR	Four items: 'Fruit' 'Vegetables' 'Fruit juice' 'Vegetable juice' Pulses and potatoes assessed separately	Previous month	Self-admin.	7 categories, ranging from 'not eaten at all' to 'eaten every day'	No
Adolescents								
Gerrits *et al.*[109]	Non-quantitative Two items within a general questionnaire	Test association of psychological variables with consumption of fatty foods and F&V	Adolescents 14–19 years	Exact classification unknown† 'Servings of fruit' 'Servings of vegetables'	Usual consumption per day	Self-admin.	4 categories, ranging from 'less than one serving a day' to '3 or more servings a day'	Yes Assessed in-line Asked to specify number of servings
HELENA[47,121]	Semi-quantitative 137-item FFQ	Assess effectiveness of an intervention to enhance the physical activity and diet of adolescents	Adolescents 13–17 years	Exact classification unknown† Groups: 'Vegetables' (pulses included), 'Fruit' One F&V juices item Potatoes assessed separately	NR	Self-admin.	10 categories Then select frequency of: 'Units per day', 'Units per week' or 'Units during the last 30 d'	Yes Assessed in-line Frequency and portion selected together for fruit juices; i.e. 1 glass/2 glass, 10 glass Photos, 4 portion sizes (amorphous foods)

Downloaded from http://www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http://www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

Table 4 *Continued*

Study	Type/no. of items	Purpose	Population	F&V items & classification	Reference period	Mode	Categories	Portion estimation
TEMPEST[115]*	Semi-quantitative Five-item FFQ within a general questionnaire	Test association of 'subjective peer norms' with eating intentions and diet	Adolescents 12–17 years	Two items: 'Fruit' 'Cooked or raw vegetables'	Per average day	Self-admin.	5 categories, ranging from 'less than 1' to 'more than 4'	Yes Assessed in-line Participants asked to report 'servings' of fruit or 'serving spoons' of cooked or raw vegetables
HBSC 2009/10[31,110]*	Non-quantitative Four-item FFQ within general questionnaire	Determine health and health behaviours and the factors that influence them[31] Investigate influence of chronological period of data collection on dietary intake[110]	Adolescents 11-, 13- and 15-year-olds	Two items: 'Fruits' 'Vegetables'	Habitual intake over a week	Self-admin.	7 categories, ranging from 'never' to 'every day, more than once'	No
I.Family Project[50]	Non-quantitative Sixty-item FFQ	Assess determinants of eating behaviour	Adolescents 12–17 years	Nine items: Four veg items (including legumes, and potatoes) Two fruit items (fresh with or without sugar) One fruit juice item Nuts and dried fruits separately (two items) under 'snacks'	Typical week over the previous month	Self admin.	7 categories, ranging from 'never/less than once a week' to '4 or more times per day'	No
Szczepanska *et al.*[114]*	Non-quantitative Twelve-item FFQ	Assess and compare dietary habits	Adolescents Age range NR	Two items: 'Fruit' 'Vegetables'	Not stated	Self-admin.	5 categories, ranging from 'never' to '3–4 times per week'	No
Larsson *et al.*[113]*	Non-quantitative Thirty-three-item FFQ within a general questionnaire	Determine prevalence of vegetarianism Compare food habits among vegetarians and omnivores	Adolescents Age range NR	Fifteen items: 'Vegetables (all except potatoes)' Eight vegetable items 'Fruits and berries (including frozen)' Five fruit items Potatoes assessed separately	12 months	Self-admin.	6 categories, ranging from 'never/rarely' to 'several times a day'	No
Children								
Antova *et al.*[116]*	Non-quantitative Five-item FFQ within a general questionnaire	Test association between diet and respiratory health	Children 7–11 years	Two items: 'Fresh fruit' (in Winter, in Summer) 'Fresh vegetables' (in Winter, in Summer) F&V seasonality assessed	NR	Self-admin.	4 categories, ranging from '>4 times per week' to 'less than once per month'	No
ENERGY[27]*	Semi-quantitative General questionnaire	Determine prevalence of EBRB Identify personal, family and school environmental correlates of EBRB	Children 10–12 years	One item: Fruit juices. 'When we say fruit juices we mean the packed fruit juice and freshly blended juice at home (100 % fruit juice)' Examples provided	Previous week Usual consumption on a day on which fruit juices are drunk	Self-admin.	7 categories per week 6 categories per day	Yes Assessed in-line Subject can select number of glasses/small cartons (250 ml) and regular cartons (330 ml) drank on a day of consumption
IDEFICS[37,118,122]*	Non-quantitative Forty-three-item FFQ	Determine the aetiology of overweight, obesity and related disorders Test association between diet and cardiovascular risk factors[139] Test association between diet and body mass[118]	Children 2–9 years (parents or guardians as proxies)	Eight items: Four vegetable items (including legumes, and potatoes) Two fruit items (fresh with or without sugar) One fruit juice item Nuts and dried fruits separately under 'snacks'	Typical week over the previous month	Self-admin.	8 categories, ranging from 'never/less than once a week' to '4 or more times per day' 'I have no idea' was also an option	No

Downloaded from http://www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http://www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

Table 4 *Continued*

Study	Type/no. of items	Purpose	Population	F&V items & classification	Reference period	Mode	Categories	Portion estimation
I.Family Project[50]	Non-quantitative Fifty-nine-item FFQ	Assess determinants of eating behaviour	Children 2–11 years (parents or guardians as proxies)	Eight items: Four vegetable items (including legumes, and potatoes) Two fruit items (fresh with or without sugar) One fruit juice item Nuts and dried fruits separately (two items) under 'snacks'	Typical week over the previous month	Self admin.	7 categories, ranging from 'never/less than once a week' to '4 or more times per day'	No
ISAAC[120]*	Non-quantitative Eight-item FFQ within a general questionnaire	Test association between dietary factors, asthma and allergy	Children 8–12 years (parents or guardians)	Four items: 'Fresh fruit' 'Raw green vegetables' 'Cooked green vegetables' 'Fruit juice'	NR	Self-admin.	5 categories, ranging from 'never' to 'once per day or more often'	No
Pro-Children/PRO GREENS[42,85–87,136]*	Non-quantitative Six-item FFQ within a general questionnaire	Assess F&V consumption and determinants of F&V consumption patterns	Children 11 years	Five items: 'Fresh fruit' 'Salad or grated vegetables' 'Raw vegetables' 'Cooked vegetables' '100 % fruit juice' Potatoes assessed separately	NR	Self-admin.	8 categories, ranging from 'never' to 'every day, more than twice a day'	No
ToyBox Children's FFQ[95–106]*	Semi-quantitative Forty-four-item FFQ	Measure the effectiveness of an intervention to prevent obesity	Children 3·5–5·5 years (parents or guardians as proxies)	Six items: 'Fruit juice, home-made, freshly squeezed' Global groups used: 'Dried fruit', 'Canned fruit', 'Fresh fruit', 'Raw veg' and 'Cooked veg' Potatoes and legumes assessed separately	12 months	Self-admin.	6 categories, ranging from '1–3 days per month' to 'every day'	Yes Assessed separately Subjects asked to select from a range of portion for each food, e.g. from '100 ml or less' to '1000 ml or more'. Examples of corresponding portions (g or ml) provided for each food item Photo book in appendix of the FFQ

CNSHS, Cross National Student Health Survey; ENERGY, EuropeaN Energy balance Research to prevent excessive weight Gain among Youth; EHBS, European Health and Behaviour Survey; ESCAREL, European Study in Non Carious Cervical Lesions; HAPIEE, Health, Alcohol and Psychosocial factors in Eastern Europe; HTT, Health in Times of Transition; IHBS, International Health and Behaviour Survey; LLH, Living Conditions, Lifestyles and Health; MGSD, Mediterranean Group for the Study of Diabetes; PRIME, Prospective Epidemiological Study of Myocardial Infarction; MEDIS, MEDiterranean Islands Study; HELENA, Healthy Lifestyle in Europe by Nutrition in Adolescence; TEMPEST, 'Temptations to Eat Moderated by Personal and Environmental Self-regulatory Tools'; HBSC, Health Behaviour in School-aged Children; IDEFICS, Identification and prevention of Dietary- and lifestyle-induced health EFfects In Children and infantS; ISAAC, International Study of Asthma and Allergies in Childhood; EPIC, European Prospective Investigation into Cancer and Nutrition; NR, not reported; EBRB, energy balance-related behaviours; F&V, fruit and vegetables; veg, vegetables; self-admin., self-administered; CATI, computer-assisted telephone interview; PAPI, paper-assisted personal interview.

*Original instrument obtained for review.

†Original instrument not obtained.

‡Information on Food4Me instrument was obtained from study authors.

size using photographs[30,36,39,50,52,53,93,95–99,101,102,104–106], absolute weights[39] or household measures[36,39,79]. Fruit was often estimated in natural units or standard portions (e.g. one piece, one fruit[82]). Other FFQ asked participants to record the quantity eaten for each food item either in tablespoons for vegetables (unless otherwise indicated as florets, slices, etc.) or by small, medium and large for fruit[82]. The ToyBox Children's FFQ asked participants to select from a pre-coded list of portion size ranges for each separate food item, providing examples of typical food items corresponding to these measurements (e.g. 1 tablespoon of prepared vegetables = 30 g). The ENERGY questionnaire asked participants to report the number of glasses or small bottles, cans and/or bottles, and specified volumes for each.

Some FFQ recorded portion size in-line; that is, participants were asked to report the frequency of a named portion[54,56,69,79,84,100,109,115]. The Willett FFQ used by Baldini *et al.*[54] provided a detailed description of what constitutes a usual serving size for each of the 120 FFQ items and the MGSD (Mediterranean Group for the Study of Diabetes) FFQ[79] outlined the usual serving size for different food categories (i.e. one serving of raw vegetables constitutes 100 g or about 1 cup).

Diet records/diet diaries

The characteristics of the identified diet records are summarised in Table 5. Diet records were typically used to determine and compare estimates of dietary intake across regions.

Seven pan-European studies[44,46,68,81,83,92,94] used diet records or diaries, either a 7 d record or three consecutive day records. With the exception of studies which used weighed records[83] or a mixed approach[81], most studies estimated portion size using photographs[30,46,91], household measures and objects (e.g. cups, spoons, etc.)[30,44,46], standard units[46] or an artificial model of foods[46,91]. Participants were typically asked to record a description of the food eaten, the time and location at which it was eaten, an estimated portion, the preparation method, brand names (or, if possible, recipe details), and weights or amounts of leftovers[83]. A few records were pre-coded or structured[46,108].

Dietary history method

The other method identified (Table 5) was the cross-check dietary history method used as part of the Seven Countries Study. Food consumption recorded at each meal occasion was used to generate a list of foods. This list was then used to assess consumption of each food on a daily, weekly or monthly basis. Tessier *et al.*[94] used a qualitative diet history method to record present diet in comparison with past diet. This was largely open-ended but included a frequency scale for vegetable consumption.

Dietary recalls

Characteristics of the identified 24-HDR are summarised in Table 6. The majority of the 24-HDR were used to determine estimates of dietary intake, comparing estimates across regions or over time. Among the nine studies which used the 24-HDR method[28,30,35,38,55,74,77,86,107], five were computerised methods. Two were conducted via face-to-face interview (i.e. SACINA and EPIC) and three were self-administered (i.e. HELENA, SACANA child and SACANA adult 24-HDR). There were six paper-based methods. Both the IDEFICS and I.Family 24-HDR programs, SACINA[38] and SACANA[50], and the program used by the HELENA study, HELENA-DIAT[35], were based on the YANA-C (Young Adolescents' Nutrition Assessment on Computer) and structured by six meals/times throughout the day. Information was entered directly into the program, with the exception of the Hungary centre where participants completed the 24-HDR at home, after which the data were entered. EPIC-SOFT differed in that before foods were entered per meal, a 'quick list' of all food and recipes consumed during that day was entered by an interviewer in chronological order, with each quick list item described and quantified.

All four computer-based 24-HDR incorporated prompts and reminders, including probes and warnings for data exceeding normal ranges; checked entries for occurrence of fruit, vegetables and sweets; or probed for food items often eaten in combination with other items[34,35] or displayed checklists containing foods easily forgotten[28]. The remaining 24-HDR were conducted via face-to-face interview and incorporated different levels of structure, pre-coding and prompts, including listing some items so that participants were specifically prompted to think about their consumption of different fruits, vegetables and juices[96,131]. Portion size was assessed largely using photographs[28,35,38,55,87], household measures[55,77], drawings of commonly used foods[55] or standard measures (i.e. cups).

Discussion

The aim of the current review was to identify the main methods used to assess intake of F&V in pan-European studies that measured dietary intake of F&V (FFQ, *n* 42; 24-HDR, *n* 11; diet record/diet diary/dietary history, *n* 7). Of the identified methods, forty-one were used to assess intake among adults, five of which assessed intake among parents/caregivers. Nine assessed intake among children ranging in age from 2 to 12 years, and seven were used among adolescents. Key differences were found to exist between methods to measure intake of F&V, which should be considered in terms of how they might affect the comprehensiveness, and the comparability, of the intake data collected. For example, the identified FFQ differed in many respects, some of which have been reported previously[152,153]. These included: (i) listing individual fruits or vegetables *v.* non-itemised, broad terms; (ii) including potatoes and legumes under the heading of

Downloaded from http:/www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http:/www.cambridge.org/core/terms.
http://dx.doi.org/10.1017/S1368980016002366

Downloaded from http://www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http://www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

Table 5 Summary of diet records: instrument purpose and characteristics

Study	Population	Purpose	Time period	Mode	Structure	Portion estimation
'Food in later life' project[68]	Adults/elderly 65–98 years	Identify factors associated with nutritional risk	Seven consecutive days	Self-admin.	None reported	Estimated
North/South Food Consumption survey[45,81]	Adults 18–64 years	Determine estimates of intake of dietary fibre and NSP[81] Establish a database of habitual food and drink consumption[45]	Seven consecutive days	Self-admin.	Recorded the types and amounts of all foods, beverages and nutritional supplements, the time and location of each 'eating occasion', the method of cooking and brand name, leftovers, recipe details and a definition of the 'eating occasion' as the subject perceived it, as either a meal or a snack Detailed instructions were given on the recording of recipes and food/drink eaten out	Mixed methods: Direct weighing, photographic atlas and food manufacturers' product data, IUNA information and data from previous UK surveys. The foods selected for inclusion in the album for use in the survey were foods consumed commonly in Ireland Portion was 'estimated' if the fieldworker made an assessment of the amount likely to have been consumed, based on their knowledge of the respondent's general eating habits observed during the recording period IUNA information: Average portions were ascertained for certain foods by the survey team. These foods included fruits, vegetables Data collected as part of previous UK studies: These included weights of vegetables
Parfitt *et al.*[83]	Adults 18–32 years	Compare dietary intake in persons on typical regional diets	5–7 d (not reported if consecutive)	Self-admin.	None reported	Estimated and weighed All portions eaten and component ingredients, where relevant, were weighed on household scales Meals eaten out portions quantified in household measures or the standard reference work Food Portion Sizes '17' was used to help estimate portion sizes
SENECA[43,44,90]	Adults/elderly 70–75 years	Examine cross-cultural differences in nutrition and lifestyle factors[43] Examine cross-cultural variations and changes in intake over time[90]	Three consecutive days	Self-admin. (3 d record) followed by face-to-face interview	1. Estimated diet record, structured by 8 meal periods 2. Frequency checklist Relevant items on Dutch frequency checklist included: Under vegetables: 'Green leafy vegetables', 'Carrots', 'Tomatoes', 'Pulses', 'Peppers', 'Potatoes', 'Other beans and peas', 'Other beets/roots', 'Salads' Under fruits: 'Fruits rich in vit. C & examples', 'Bananas', 'Carotene rich fruit & examples', 'Dried fruits', 'Fatty fruits', 'Other fruits'	Estimated and weighed Portion sizes recorded in household measures and checked by weighing Beverages portion size estimated using glasses or cups

Downloaded from http://www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http://www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

Table 5 *Continued*

Study	Population	Purpose	Time period	Mode	Structure	Portion estimation
Seven Countries Study[4,91,92]	Adults/elderly 40–59 years (at enrolment)	Compare diets among diabetic and non-diabetic men[91] Test association of F&V and fish with COPD[4,92]	Cross-check dietary history Method concerning the month preceding the interview	Face-to-face interview	Usual food consumption pattern of a person was assessed on daily basis during week and weekend days, i.e. about the foods used at breakfast, lunch, dinner and between meals. Based on list of all food compiled from this, they recorded what was eaten on a daily, weekly or monthly basis Checklist with an extensive number of foods was used to record the frequencies and amounts of foods consumed	Estimated Finland: photos The Netherlands: by a portable scale Italy: by artificial models of different foods in Italy
Tessier *et al.*[94]*	Adults/mothers 50–91 years Adults/daughters 22–60 years	Examine changes in diet intake over time	Qualitative questionnaire. Not stated	Face-to-face interview	Open-ended questions. Four-category frequency scale for vegetables: never; rarely; sometimes; often; always	No
WHO-MONICA EC/ MONICA Project optional nutrition study[46,108,123]	Adults/men 45–64 years	Monitor trends in risk factors for CVD, including diet[108] Assess snack patterns[123]	Three consecutive days (Belgium, France, Northern Ireland, Finland, Italy) Seven consecutive days (Germany, Denmark, UK) Three consecutive 24-HDR (Barcelona)	Self-admin. Interview-administered or telephone-administered for Barcelona	Generally week and weekend days representative for the whole week were included Data collection in several seasons Recorded preparation method, type of food or brand names, and recipes	Estimated Picture book/food models (France, Spain, Italy, Germany) Household measures (Germany, France, Spain, Finland, UK, Italy, Denmark) Standard units (Germany, France, Finland, Spain, UK, Italy, Denmark)

SENECA, Survey in Europe on Nutrition and the Elderly; a Concerted Action; MONICA, Multinational MONItoring of trends and determinants in CArdiovascular disease; F&V, fruit and vegetables; COPD, chronic obstructive pulmonary disease; 24-HDR, 24 h recall; self-admin., self-administered, vit., vitamin; IUNA, Irish Universities Nutrition Alliance.
*Original instrument obtained for review.

Downloaded from http://www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http://www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

Table 6 Summary of dietary recalls: instrument purpose and characteristics

Study	Population	Purpose	Method of adminsitration	Structure	Prompts	Portion estimation
Adults						
EPIC[28,63]	Adults 30–70 years	Provide comparable food consumption data between several European countries	EPIC-SOFT 1 × 24-HDR Computerised, face-to-face interview	1. 'Quick list' chronological entry of all foods and recipes consumed during day 2. Foods are entered per meal 3. Each 'quick list' item is described and quantified	Yes. Program mediated Checklist of foods easily forgotten is displayed on screen	Estimated Six quantification methods including photos (2–6 portion sizes), shapes, household measurements, standard units, standard portions, volume method and 'unknown' method
Baltic project[55]	Adults 19–65 years	Assess macronutrient and diet intakes including F&V consumption	1 × 24-HDR Interview-administered	Not indicated	NR	Estimated Household measures and photographs and/or drawings of commonly used foods
Van Diepen *et al.*[107]	Adults Age range NR	Assess and compare Mediterranean diet adherence	Two consecutive 24-HDR Mode NR	NR	NR	NR
LiVicordia[77]	Adults/men 50 years old	Assess and compare mean estimates of food intake	1 × 24-HDR Face-to-face interview	Open-ended Used a checklist for 'Between meals' consumption which included 'Fruit (apples, bananas)'	Yes	Estimated Household measures; 1, 5, 15 and 100 ml; a ruler; packages of butter and margarine 5 and 10 g; and glass with 150 ml water
I.Family Project[50,74] SACANA	Adults/parents No age range determined	Identify determinants of food choice, lifestyle and health	1 × 24-HDR Computerised, self-admin.	Meal occasions, one breakfast, one lunch, one dinner; snacks and drinks as needed	Yes. Program mediated	Accurate portion size in g or ml and graphical images and photos
Pro-Children[42,86,87,136]*/ PRO GREENS[85]	Adults/parents	Assess F&V consumption and determinants of F&V consumption patterns	1 × 24-HDR Self-admin.	6 time intervals 'Did you eat or drink anything yesterday morning? (yes/no)'. 'What was it?' Pre-coded with some fruit and vegetables items and asked e.g. 'Did you eat fruit yesterday morning?'	NR	Estimated Photos, 3 portion sizes (for salad, for cooked vegetables and for fruit salad) Asked to report amounts in terms of the number of pieces, slices or portions eaten, e.g. number of pieces of fruit
Adolescents						
HELENA[34,35]	Adolescents 13–17 years	Assess food and nutrient intake	HELENA-DIAT Two non-consecutive 24-HDR (within 2 weeks) Computerised, self-admin.	6 meal occasions	Yes. Program mediated Checked entries for occurrence of fruit, vegetables and sweets and asked 'if really not consumed' Probed for foods commonly eaten in conjunction with others	Estimated Photos Several measurement units (e.g. spoon, can, glass, grams, etc.) used and, if suitable, more than one measurement unit is present for the same food item
Children						
EYHS[30 117] (Based on copy of Danish 'Kostkema', i.e. may not be same as Swedish 24-HDR)	Children 9 and 15 years	Examine personal, environmental, and lifestyle influences on cardiovascular risk factors Examine changes in diet intake over time[117]	1 × 24-HDR Face-to-face interview	24-HDR preceded by a 1 d qualitative, parent-assisted food record the previous day 24-HDR food checklist and recorded the type, description of food and location where eaten	Yes, during interview	Estimated Different-sized drinking glasses, plates, spoons and food pictures of most common foods and food groups in different portion sizes were used to estimate food quantities
IDEFICS[37,119,135]	Children 2–9 years (parents or guardians as proxies)	Determine the aetiology of overweight, obesity and related disorder	SACINA 1 × 24-HDR Computerised, face-to-face interview Hungary: self-admin. 24-HDR at home	6 meal occasions	Yes. Program mediated	Estimated Photos
Pro-Children[42,86,87,136]/ PRO GREENS[85]	Children 11 years	Assess F&V consumption and determinants of F&V consumption patterns	1 × 24-HDR Self-admin.	6 time intervals 'Did you eat or drink anything yesterday morning? (yes/no)'. 'What was it?' Pre-coded with some fruit and vegetables items and asked e.g. 'Did you eat fruit yesterday morning?'	NR	Estimated Photos, three portion sizes (for salad, for cooked vegetables and for fruit salad) Asked to report amounts in terms of the number of pieces, slices or portions eaten, e.g. number of pieces of fruit
I.Family Project[50,74]	Children and adolescents 8 years or older	Identify determinants of food choice and lifestyle	SACANA 1 × 24-HDR Computerised, self-admin.	Meal occasions, one breakfast, one lunch, one dinner; snacks and drinks as needed	Yes. Program mediated	Accurate portion size in g or ml and graphical images and photos

EPIC, European Prospective Investigation into Cancer and Nutrition; HELENA, Healthy Lifestyle in Europe by Nutrition in Adolescence; EYHS, European Youth Heart Study; 24-HDR, 24 h recall; IDEFICS, Identification and prevention of Dietary- and lifestyle-induced health EFfects In Children and infantS; NR, not reported; F&V, fruit and vegetables; self-admin., self-administered.
*Original instrument obtained for review.

vegetables; (iii) variation in the number and range of items (from about twenty to forty specific items to fewer than five broad items); (iv) variation in the number and range of frequency categories; and (v) variation in the method of portion size estimation.

While dietary assessment methods used in US[156] or UK[157] studies have previously been compiled, the current review is the first to specifically focus on systematically identifying and describing instruments that can be used to assess intake of F&V in pan-European studies. As European-wide interventions to promote the consumption of F&V are further developed, valid instruments that can assess and monitor intake in a standardised and comparable way across Europe are essential. In order to identify instruments which would be most promising to use in future pan-European studies to measure F&V, and those to include in the DEDIPAC toolbox, two selection criteria were applied: (i) the instrument was tested for validity and/or reproducibility; and (ii) the instrument was used in more than two countries simultaneously which represented a range of European regions.

According to these criteria, six instruments appear to be suitable to assess intake of F&V among adults in pan-European studies. However, only two of the studies had been validated for F&V intake (EPIC-SOFT and Food4Me), using biomarkers and 4 d diet records, respectively. All three instruments selected to assess intake among adolescents, the HELENA-DIAT instrument, the HELENA online FFQ and the HBSC FFQ, had been validated, using 24-HDR (HELENA instruments) and both 24-HDR and 7 d diet record (HBSC) as reference methods, with good agreement but some overestimation of intakes by the HELENA and HBSC FFQ. Five instruments were selected to assess intake among children; however, just three instruments were validated for F&V intake (IDEFICS FFQ, Pro-Children and ToyBox), using 24-HDR (IDEFICS), 7 d (Pro-Children) and 3 d (ToyBox) diet records as the reference method, demonstrating moderately good ranking for food groups by the Pro-Children instrument, moderate relative validity for ToyBox and low agreement of the IDEFICS FFQ with 24-HDR.

As already stated, the results of the current review will feed into the development of the DEDIPAC toolbox of dietary intake assessment methods, which will provide a basis for appraising and selecting suitable instruments for use in future pan-European studies. However, before selecting from the eight validated instruments shortlisted herein, the quality of the validity and/or reproducibility studies performed for the instrument should be considered to assess the suitability of the instruments identified for the study in question; for example, judging the reference method used (i.e. biomarkers, long-term or short-term dietary assessment method) and the statistics used to assess validity (i.e. whether compared at group level, mean/median differences, or assessed using crude, energy-adjusted, de-attenuated or intraclass correlations)[156]. Although a tool may have been tested for validity in several countries, ideally it should be validated in the population in which it is to be used. Although no selection was made based on the comprehensiveness of the instrument, this may be another criterion to consider before utilising the instrument in question; that is, based on the cut-off of five items used by Cook *et al.*[151], the ENERGY parent and child instruments, the ToyBox parent's questionnaire and the HBSC FFQ were ranked as having low comprehensiveness for F&V.

The purpose of the dietary assessment should also be taken into consideration. Most of the identified FFQ were used to identify determinants of dietary intake or examine diet–disease associations. This contrasts with 24-HDR and diet records, which were primarily used to assess intake for cross-cultural comparisons or over time. It is generally accepted[153] that diet records, 24-HDR and dietary history methods, unlike FFQ, are suitable for cross-cultural comparisons. FFQ are typically designed to be population-specific, encapsulating local dietary customs and foods, and may not be the ideal instrument to use across several countries[153]. However, this also must be balanced against the feasibility of using the instrument; namely, resource-demanding methods such as interview-administered 24-HDR (EPIC-SOFT) compared with self-completed 24-HDR (HELENA-DIAT) or FFQ (Food4Me, IDEFICS, HBSC, HELENA, Pro-Children and ToyBox instruments), which needs to be taken into consideration to determine whether an instrument can be used effectively to assess intake of F&V in a chosen pan-European population.

Owing to the lack of an appraisal tool to rate dietary assessment instruments on the basis of their characteristics, the quality of the identified instruments was not assessed as part of the current review. Future work should consider developing a standardised approach to appraisal which would greatly aid any comparison of quality across dietary assessment tools, particularly where validation studies are absent. Comparing the characteristics of the instruments identified in the current review could provide a basis for agreement on such quality standards; for example, requiring instruments to assess portion size and, where they do, that a consistent approach be used – defining servings in units which are understandable to participants (e.g. '15 g or tablespoon' of cooked vegetables, 'beaker = 225 ml' of fruit juice) or through use of a standardised photographic food atlas.

It may also be possible to decide how specific FFQ questions, including the format of these questions, could be better standardised across FFQ used in pan-European studies, even if the FFQ themselves are country-specific. As highlighted, the identified FFQ varied considerably on comprehensiveness (number of items) and detail (use of broad terms like 'fruit' or 'vegetables' *v.* specific items). While cut-offs such as that used by Cook *et al.*[151] may be applied, any judgement on comprehensiveness must be balanced against the purpose of the assessment; for

Downloaded from http:/www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http:/www.cambridge.org/core/terms.
http://dx.doi.org/10.1017/S1368980016002366

example, is the aim is to examine dietary patterns overall, rather than focus specifically on health and disease associations with individual fruits and vegetables, and is there additional benefit to be gained from providing an exhaustive list? However, where broad terms are included, this needs to be supplemented with adequate explanation or an inventory of items intended to fall under these terms, to avoid the possibility of participant misunderstanding and consequently variation across countries and regions. For example, some FFQ listed fruit or vegetable juice but did not always specify 100 % fruit or vegetable juice. Similarly, some did not clarify whether potatoes or legumes were covered by a broader term such as 'vegetables'.

The current review has a number of strengths and limits. A comprehensive search strategy was used that aimed to identify all pan-European studies measuring the intake of F&V among children and adults, and their associated assessment instruments. The search was supplemented by hand-searching reference lists, sourcing further instruments through contact with study authors, and reviewing the results of concurrently occurring systematic literature reviews. Where possible, a copy of the original instrument was obtained to facilitate the description of the methods. However, although a comprehensive search was conducted, the possibility that all relevant articles were not identified cannot be excluded. The review is limited in its focus to pan-European studies, as the aim was to identify instruments used in European populations and to provide a selection of methods which may be applied to future studies based in these countries. However, this does not preclude the fact that additional instruments and innovative methods[157] that have been used and validated as part of large-scale non-European studies, such as the US NHANES (National Health and Nutrition Examination Survey)[158], may be suitable for assessing intakes across Europe. In some cases, a copy of the original instrument or article that detailed characteristics of the assessment method could not be identified and the description provided may be limited as a result. This being said, the primary aim of the review was to identify assessment instruments. Therefore the results serve as a valuable reference. As mentioned, no quality appraisal of the identified instruments could be conducted. However, by indicating which instruments were validated and/or tested for reproducibility, summarising these results and applying additional criteria, the review has selected a number of potential instruments and provided a basis for determining the suitability of instruments for use in future studies.

Conclusion

The present review has identified a range of instruments to assess intake of F&V and indicates that a large degree of variability exists between currently available instruments. To standardise the measurement of F&V intake between European countries, instruments should use a consistent approach to assessing F&V; for example, using itemised terms and, when non-itemised broad terms are used, clarifying whether potatoes and legumes/pulses are captured by these terms. The current review has indicated eight instruments validated for F&V intake that may be suitable to assess the intake of F&V among adult, child or adolescent populations. These methods have been used in pan-European populations, encompassing a range of European regions, and should be considered for use by future studies focused on evaluating consumption of F&V.

Acknowledgements

Financial support: The preparation of this paper was supported by the DEDIPAC Knowledge Hub. This work was supported by the Joint Programming Initiative 'Healthy Diet for a Healthy Life'. The funding agency supporting this work was The Health Research Board (HRB), Ireland (DEDIPAC/2013/1). *Conflict of interest:* L.F.A. was co-author on the Pro-Children validity and reproducibility study. *Authorship:* F.R. planned and conducted the review, and drafted and revised the paper. K.R. planned and conducted the review, and drafted the paper. I.J.P. drafted and revised the paper. M.B.S. contributed to the planning, and drafted and revised the paper. L.F.A. contributed to the planning, and drafted and revised the paper. A.G. drafted and revised the paper. P.v.V. drafted and revised the paper. S.E. conducted the review of validation data, and drafted and revised the paper. P.D. conducted the review of validation data, and drafted and revised the paper. N.W.-D. conducted the review of validation data, and drafted and revised the paper. J.M.H. contributed to the planning, and drafted and revised the paper. *Ethics of human subject participation:* Not applicable.

Supplementary material

To view supplementary material for this article, please visit http://dx.doi.org/10.1017/S1368980016002366

References

1. Aburto NJ, Ziolkovska A, Hooper L *et al.* (2013) Effect of lower sodium intake on health: systematic review and meta-analyses. *BMJ* **346**, f1326.
2. Hanson C, Rutten EP, Wouters EF *et al.* (2013) Diet and vitamin D as risk factors for lung impairment and COPD. *Transl Res* **162**, 219–236.
3. World Health Organization (2003) *Diet, Nutrition and the Prevention of Chronic Diseases. Joint WHO/FAO Expert Consultation. WHO Technical Report Series* no. 916. Geneva: WHO.
4. Walda IC, Tabak C, Smit HA *et al.* (2002) Diet and 20-year chronic obstructive pulmonary disease mortality in middle-aged men from three European countries. *Eur J Clin Nutr* **56**, 638–643.

Downloaded from http:/www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http:/www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

5. Cecchini M, Sassi F, Lauer JA *et al.* (2010) Tackling of unhealthy diets, physical inactivity, and obesity: health effects and cost-effectiveness. *Lancet* **376**, 1775–1784.
6. Dauchet L, Amouyel P, Hercberg S *et al.* (2006) Fruit and vegetable consumption and risk of coronary heart disease: a meta-analysis of cohort studies. *J Nutr* **136**, 2588–2593.
7. Joshipura KJ, Hu FB, Manson JE *et al.* (2001) The effect of fruit and vegetable intake on risk for coronary heart disease. *Ann Intern Med* **134**, 1106–1114.
8. Waxman A (2004) WHO global strategy on diet, physical activity and health. *Food Nutr Bull* **25**, 292–302.
9. Food and Agriculture Organization of the United Nations & World Health Organization (2004) *Fruit and Vegetables for Health: Report of a Joint FAO/WHO Workshop, 1–3 September 2004, Kobe, Japan*. Geneva: WHO.
10. Agudo A (2005) *Measuring Intake of Fruit and Vegetables. Background Paper for the Joint FAO/WHO Workshop on Fruit and Vegetables for Health, 1–3 September 2004, Kobe, Japan*. Barcelona: Unit of Epidemiology, Catalan Institute of Oncology.
11. Blanquer M, Garcia-Alvarez A, Ribas-Barba L *et al.* (2009) How to find information on national food and nutrient consumption surveys across Europe: systematic literature review and questionnaires to selected country experts are both good strategies. *Br J Nutr* **101**, Suppl. 2, S37–S50.
12. Roark RA & Niederhauser VP (2013) Fruit and vegetable intake: issues with definition and measurement. *Public Health Nutr* **16**, 2–7.
13. National and Kapodistrian University of Athens (2014) DAFNE. Data Food Networking. http://www.nut.uoa.gr/dafnesoftweb/ (accessed September 2014).
14. Norfoods project (2014) A Nordic approach to Food Composition Data. http://www.fooddata.dk/norfoods/?Nordic_food_data (accessed September 2014).
15. Castenmiller J & West CE (1995) *Report of the Third Annual FLAIR-Eurofoods-Enfant Project Meeting, Vilamoura, Portugal, 1993*. Wageningen: FLAIR-Eurofoods-Enfant Project (1994).
16. Working Group on Food Data Management and Interchange (2000) *COST Action 99. Research Action on Food Consumption and Composition Data. Eurofoods Recommendations for Food Composition Database Management and Data Interchange*. Luxembourg: Office for Official Publications of the European Communities.
17. EFCOSUM Group (2001) *European Food Consumption Survey Method. Final Report. TNO Report* no. V3766. Zeist: TNO Nutrition and Food Research.
18. Riboli E & Kaaks R (1997) The EPIC Project: rationale and study design. European Prospective Investigation into Cancer and Nutrition. *Int J Epidemiol* **26**, Suppl. 1, S6–S14.
19. Innovative Dietary Assessment Methods in Epidemiological Studies and Public Health (2010) *Dietary Assessment Methods: State of the Art Report*. Potsdam-Rehbrücke: German Institute of Human Nutrition (DIfE).
20. European Food Safety Authority (2009) General principles for the collection of national food consumption data in the view of a pan-European dietary survey. *EFSA J* **7**, 1435.
21. European Food Safety Authority (2014) Guidance on the EU Menu methodology. *EFSA J* **12**, 3944.
22. Determinants of Diet and Physical Activity Knowledge Hub (2014) Home page. https://www.dedipac.eu/ (accessed September 2014).
23. Lakerveld J, van der Ploeg H, Kroeze W *et al.* (2014) Towards the integration and development of a cross-European research network and infrastructure: the DEterminants of DIet and Physical ACtivity (DEDIPAC) Knowledge Hub. *Int J Behav Nutr Phys Act* **11**, 143.
24. Harrington JM, Riordan F & Ryan K (2014) What are the assessment methods used to determine dietary intake of fruit and vegetables in adults (>18 years) and children in European countries, according to pan-European studies involving two or more European countries? http://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42014012947 (accessed August 2016).
25. Council of Europe (2014) 47 Member States. http://www.coe.int/en/web/portal/47-members-states (accessed September 2014).
26. United Nations (2014) Composition of macro geographical (continental) regions, geographical sub-regions, and selected economic and other groupings. http://unstats.un.org/unsd/methods/m49/m49regin.htm (accessed March 2014).
27. van Stralen MM, te Velde SJ, Singh AS *et al.* (2011) EuropeaN Energy balance Research to prevent excessive weight Gain among Youth (ENERGY) project: design and methodology of the ENERGY cross-sectional survey. *BMC Public Health* **11**, 65.
28. Slimani N, Deharveng G, Charrondiere RU *et al.* (1999) Structure of the standardized computerized 24-h diet recall interview used as reference method in the 22 centers participating in the EPIC project. European Prospective Investigation into Cancer and Nutrition. *Comput Methods Programs Biomed* **58**, 251–266.
29. Riboli E, Hunt KJ, Slimani N *et al.* (2002) European Prospective Investigation into Cancer and Nutrition (EPIC): study populations and data collection. *Public Health Nutr* **5**, 1113–1124.
30. Riddoch C, Edwards D, Page A *et al.* (2005) The European Youth Heart Study – cardiovascular disease risk factors in children: rationale, aims, study design, and validation of methods. *J Phys Act Health* **2**, 115–129.
31. Currie C, Griebler R, Inchley J *et al.* (2010) *Health Behaviour in School-Aged Children (HBSC) Study Protocol: Background, Methodology and Mandatory Items for the 2009/10 Survey*. Edinburgh/Vienna: CAHRU/LBIHPR.
32. Moreno LA, De Henauw S, Gonzalez-Gross M *et al.* (2008) Design and implementation of the Healthy Lifestyle in Europe by Nutrition in Adolescence Cross-Sectional Study. *Int J Obes (Lond)* **32**, Suppl. 5, S4–S11.
33. Moreno LA, Gonzalez-Gross M, Kersting M *et al.* (2008) Assessing, understanding and modifying nutritional status, eating habits and physical activity in European adolescents: the HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) Study. *Public Health Nutr* **11**, 288–299.
34. Vereecken CA, Covents M, Matthys C *et al.* (2005) Young adolescents' nutrition assessment on computer (YANA-C). *Eur J Clin Nutr* **59**, 658–667.
35. Vereecken CA, Covents M, Sichert-Hellert W *et al.* (2008) Development and evaluation of a self-administered computerized 24-h dietary recall method for adolescents in Europe. *Int J Obes (Lond)* **32**, Suppl. 5, S26–S34.
36. Vereecken CA, De Bourdeaudhuij I, Maes L *et al.* (2010) The HELENA online food frequency questionnaire: reproducibility and comparison with four 24-h recalls in Belgian-Flemish adolescents. *Eur J Clin Nutr* **64**, 541–548.
37. Ahrens W, Bammann K, Siani A *et al.* (2011) The IDEFICS cohort: design, characteristics and participation in the baseline survey. *Int J Obes (Lond)* **35**, Suppl. 1, S3–S15.
38. Bel-Serrat S, Mouratidou T, Pala V *et al.* (2014) Relative validity of the Children's Eating Habits Questionnaire–food frequency section among young European children: the IDEFICS Study. *Public Health Nutr* **17**, 266–276.
39. van Dongen MC, Lentjes MA, Wijckmans NE *et al.* (2011) Validation of a food-frequency questionnaire for Flemish and Italian-native subjects in Belgium: the IMMIDIET study. *Nutrition* **27**, 302–309.
40. Weiland SK, Bjorksten B, Brunekreef B *et al.* (2004) Phase II of the International Study of Asthma and Allergies in

Downloaded from http:/www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http:/www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

Childhood (ISAAC II): rationale and methods. *Eur Respir J* **24**, 406–412.
41. Nordic Council of Ministers (2003) *The NORBAGREEN 2002 Study. Consumption of Vegetables, Potatoes, Fruit, Bread and Fish in the Nordic and Baltic countries. Contract* no. TemaNord 2003:556. Århus: Nordic Council of Ministers.
42. Haraldsdottir J, Thorsdottir I, de Almeida MDV *et al.* (2005) Validity and reproducibility of a precoded questionnaire to assess fruit and vegetable intake in European 11- to 12-year-old schoolchildren. *Ann Nutr Metab* **49**, 221–227.
43. de Groot LC, Hautvast JG & van Staveren WA (1992) Nutrition and health of elderly people in Europe: the EURONUT-SENECA Study. *Nutr Rev* **50**, 185–194.
44. de Groot CPGM & van Staveren WA (1988) *Nutrition and the Elderly. A European Collaborative Study in Cooperation with the World Health Organization (WHO-SPRA) and the International Union of Nutritional Sciences (IUNS) Committee on Geriatric Nutrition. Manual of Operations. EURONUT Report* no. 11. Wageningen: EURONUT.
45. Harrington KE, Robson PJ, Kiely M *et al.* (2001) The North/South Ireland Food Consumption Survey: survey design and methodology. *Public Health Nutr* **4**, 1037–1042.
46. Haveman-Nies A, Bokje E, Ocke M *et al.* (2003) *MONICA Optional Study on Nutrition: The Dietary Assessment Methodology*. Bilthoven: RIVM.
47. Maes L, Cook TL, Ottovaere C *et al.* (2011) Pilot evaluation of the HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) Food-O-Meter, a computer-tailored nutrition advice for adolescents: a study in six European cities. *Public Health Nutr* **14**, 1292–1302.
48. Kolarzyk E, Shpakou A, Kleszczewska E *et al.* (2012) Nutritional status and food choices among first year medical students. *Central Eur J Med* **7**, 396–408.
49. Hebestreit A, Eiben G, Reineke A *et al.* (c.2014) Computer based 24 HDR Dietary Recall: the SACINA program (draft). Bremen Institue for Prevention Research and Social Medicine (BIPS), University of Bremen, Bremen, Germany; Department of Public Health and Community Medicine, Goteborg University, Sweden; Department of Public Health, Faculty of Medicine and Health Sciences, Ghent University, Belgium.
50. I.Family (2014) Home page. http://www.ifamilystudy.eu/ (accessed September 2014).
51. Celis-Morales C, Livingstone KM, Marsaux CF *et al.* (2015) Design and baseline characteristics of the Food4Me study: a web-based randomised controlled trial of personalised nutrition in seven European countries. *Genes Nutr* **10**, 450.
52. Forster H, Fallaize R, Gallagher C *et al.* (2014) Online dietary intake estimation: the Food4Me food frequency questionnaire. *J Med Internet Res* **16**, e150.
53. Fallaize R, Forster H, Macready AL *et al.* (2014) Online dietary intake estimation: reproducibility and validity of the Food4Me food frequency questionnaire against a 4-day weighed food record. *J Med Internet Res* **16**, e190.
54. Baldini M, Pasqui F, Bordoni A *et al.* (2009) Is the Mediterranean lifestyle still a reality? Evaluation of food consumption and energy expenditure in Italian and Spanish university students. *Public Health Nutr* **12**, 148–155.
55. Pomerleau J, McKee M, Robertson A *et al.* (2001) Macronutrient and food intake in the Baltic republics. *Eur J Clin Nutr* **55**, 200–207.
56. Behanova M, Nagyova I, Katreniakova Z *et al.* (2014) Health-risk behaviours in deprived urban neighbourhoods: a comparison between Slovak and Dutch cities. *Int J Public Health* **59**, 405–414.
57. El Ansari W, Stock C & Mikolajczyk RT (2012) Relationships between food consumption and living arrangements among university students in four European countries – a cross-sectional study. *Nutr J* **11**, 28.
58. Mikolajczyk RT, El Ansari W & Maxwell AE (2009) Food consumption frequency and perceived stress and depressive symptoms among students in three European countries. *Nutr J* **8**, 31.
59. Hooper R, Heinrich J, Omenaas E *et al.* (2010) Dietary patterns and risk of asthma: results from three countries in European Community Respiratory Health Survey-II. *Br J Nutr* **103**, 1354–1365.
60. Steptoe A & Wardle J (2001) Locus of control and health behaviour revisited: a multivariate analysis of young adults from 18 countries. *Br J Psychol* **92**, 659–672.
61. Vrieling A, Verhage BAJ, Van Duijnhoven FJB *et al.* (2009) Fruit and vegetable consumption and pancreatic cancer risk in the European Prospective Investigation into Cancer and Nutrition. *Int J Cancer* **124**, 1926–1934.
62. Agudo A, Slimani N, Ocke MC *et al.* (2002) Consumption of vegetables, fruit and other plant foods in the European Prospective Investigation into Cancer and Nutrition (EPIC) cohorts from 10 European countries. *Public Health Nutr* **5**, 1179–1196.
63. Crispim SP, Geelen A, Souverein OW *et al.* (2011) Biomarker-based evaluation of two 24-h recalls for comparing usual fish, fruit and vegetable intakes across European centers in the EFCOVAL Study. *Eur J Clin Nutr* **65**, Suppl. 1, S38–S47.
64. Bartlett DW, Lussi A, West NX *et al.* (2013) Prevalence of tooth wear on buccal and lingual surfaces and possible risk factors in young European adults. *J Dent* **41**, 1007–1013.
65. Esteve J, Riboli E, Pequignot G *et al.* (1996) Diet and cancers of the larynx and hypopharynx: the IARC multicenter study in southwestern Europe. *Cancer Causes Control* **7**, 240–252.
66. Prattala R, Paalanen L, Grinberga D *et al.* (2007) Gender differences in the consumption of meat, fruit and vegetables are similar in Finland and the Baltic countries. *Eur J Public Health* **17**, 520–525.
67. Paalanen L, Prattala R, Alfthan G *et al.* (2014) Vegetable and fruit consumption, education and plasma vitamin C concentration in Russian and Finnish Karelia, 1992–2002. *Public Health Nutr* **17**, 2278–2286.
68. de Morais C, Oliveira B, Afonso C *et al.* (2013) Nutritional risk of European elderly. *Eur J Clin Nutr* **67**, 1215–1219.
69. Galanti MR, Hansson L, Bergstrom R *et al.* (1997) Diet and the risk of papillary and follicular thyroid carcinoma: a population-based case–control study in Sweden and Norway. *Cancer Causes Control* **8**, 205–214.
70. Boylan S, Welch A, Pikhart H *et al.* (2009) Dietary habits in three Central and Eastern European countries: the HAPIEE study. *BMC Public Health* **9**, 439.
71. Abe SK, Stickley A, Roberts B *et al.* (2013) Changing patterns of fruit and vegetable intake in countries of the former Soviet Union. *Public Health Nutr* **16**, 1924–1932.
72. Hupkens CLH, Knibbe RA & Drop MJ (1997) Social class differences in women's fat and fibre consumption: a cross-national study. *Appetite* **28**, 131–149.
73. Determinants of eating behaviour in European children, adolescents and their parents (I.Family) (2012–2017) Diet Questionnaire. EC FP7 Grant Agreement no. 266044.
74. Determinants of eating behaviour in European children, adolescents and their parents (I.Family) (2012–2017) SACANA. EC FP7 Grant Agreement no. 266044.
75. Grant N, Wardle J & Steptoe A (2009) The relationship between life satisfaction and health behavior: a cross-cultural analysis of young adults. *Int J Behav Med* **16**, 259–268.
76. Pounis G, de Lorgeril M, Salen P *et al.* (2014) Dietary patterns and fatty acids levels of three European

Downloaded from http:/www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http:/www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

populations. Results from the IMMIDIET study. *Nutr Metab Cardiovasc Dis* **24**, 883–890.
77. Elwing B, Kullberg C, Kucinskiene Z *et al.* (2001) A comparative study of food intake between Lithuanian and Swedish middle-aged men: the LiVicordia study. *Scand J Nutr/Naringsforskning* **45**, 126–130.
78. Tyrovolas S, Psaltopoulou T, Pounis G *et al.* (2011) Nutrient intake in relation to central and overall obesity status among elderly people living in the Mediterranean islands: the MEDIS study. *Nutr Metab Cardiovasc Dis* **21**, 438–445.
79. Karamanos B, Thanopoulou A, Angelico F *et al.* (2002) Nutritional habits in the Mediterranean Basin. The macronutrient composition of diet and its relation with the tradiational Mediterranean diet. Multi-centre study of the Mediterranean Group for the study of diabetes (MGSD). *Eur J Clin Nutr* **56**, 983–991.
80. Petkeviciene J, Simila M, Becker W *et al.* (2009) Validity and reproducibility of the NORBAGREEN food frequency questionnaire. *Eur J Clin Nutr* **63**, 141–149.
81. Galvin M, Kiely M, Harrington K *et al.* (2001) The North/South Ireland Food Consumption Survey: the dietary fibre intake of Irish adults. *Public Health Nutr* **4**, 1061–1068.
82. O'Neill ME, Carroll Y, Corridan B *et al.* (2001) A European carotenoid database to assess carotenoid intakes and its use in a five-country comparative study. *Br J Nutr* **85**, 499–507.
83. Parfitt VJ, Rubba P, Bolton C *et al.* (1994) A comparison of antioxidant status and free radical peroxidation of plasma lipoproteins in healthy young persons from Naples and Bristol. *Eur Heart J* **15**, 871–876.
84. Dauchet L, Ferrieres J, Arveiler D *et al.* (2004) Frequency of fruit and vegetable consumption and coronary heart disease in France and Northern Ireland: the PRIME study. *Br J Nutr* **92**, 963–972.
85. Lehto E, Ray C, Te Velde S *et al.* (2015) Mediation of parental educational level on fruit and vegetable intake among schoolchildren in ten European countries. *Public Health Nutr* **18**, 89–99.
86. Klepp KI, Perez-Rodrigo C, De Bourdeaudhuij I *et al.* (2005) Promoting fruit and vegetable consumption among European schoolchildren: rationale, conceptualization and design of the Pro Children Project. *Ann Nutr Metab* **49**, 212–220.
87. Yngve A, Wolf A, Poortvliet E *et al.* (2005) Fruit and vegetable intake in a sample of 11-year-old children in 9 European countries: the Pro Children cross-sectional survey. *Ann Nutr Metab* **49**, 236–245.
88. Rylander R, Axelsson G, Megevand Y *et al.* (1999) Dietary habits for non-smoking females living with smokers or non-smokers. *Eur J Public Health* **9**, 142–145.
89. Nes M, van Staveren WA, Zajkas G *et al.* (1991) Validity of the dietary history method in elderly subjects. Euronut SENECA investigators. *Eur J Clin Nutr* **45**, Suppl. 3, 97–104.
90. Schroll K, Moreiras-Varela O, Schlettwein-Gsell D *et al.* (1997) Cross-cultural variations and changes in food-group intake among elderly women in Europe: results from the Survey in Europe on Nutrition and the Elderly a Concerted Action (SENECA). *Am J Clin Nutr* **65**, 4 Suppl., S1282–S1289.
91. Virtanen SM, Feskens EJM, Rasanen L *et al.* (2000) Comparison of diets of diabetic and non-diabetic elderly men in Finland, The Netherlands and Italy. *Eur J Clin Nutr* **54**, 181–186.
92. Tabak C, Feskens EJM, Heederik D *et al.* (1998) Fruit and fish consumption: a possible explanation for population differences in COPD mortality (The Seven Countries Study). *Eur J Clin Nutr* **52**, 819–825.
93. Terry MB, Howe G, Pogoda JM *et al.* (2009) An international case–control study of adult diet and brain tumor risk: a histology-specific analysis by food group. *Ann Epidemiol* **19**, 161–171.
94. Tessier S & Gerber M (2005) Factors determining the nutrition transition in two Mediterranean islands: Sardinia and Malta. *Public Health Nutr* **8**, 1286–1292.
95. Androutsos O, Apostolidou E, Iotova V *et al.* (2014) Process evaluation design and tools used in a kindergarten-based, family-involved intervention to prevent obesity in early childhood. The ToyBox-study. *Obes Rev* **15**, 74–80.
96. Androutsos O, Katsarou C, Payr A *et al.* (2014) Designing and implementing teachers' training sessions in a kindergarten-based, family-involved intervention to prevent obesity in early childhood. The ToyBox-study. *Obes Rev* **15**, 48–52.
97. De Craemer M, De Decker E, De Bourdeaudhuij I *et al.* (2014) Applying the Intervention Mapping protocol to develop a kindergarten-based, family-involved intervention to increase European preschool children's physical activity levels: the ToyBox-study. *Obes Rev* **15**, 14–26.
98. De Miguel-Etayo P, Mesana MI, Cardon G *et al.* (2014) Reliability of anthropometric measurements in European preschool children: the ToyBox-study. *Obes Rev* **15**, Suppl. 3, 67–73.
99. Duvinage K, Ibrügger S, Kreichauf S *et al.* (2014) Developing the intervention material to increase physical activity levels of European preschool children: the ToyBox-study. *Obes Rev* **15**, Suppl. 3, 27–39.
100. Gonzalez-Gil EM, Mouratidou T, Cardon G *et al.* (2014) Reliability of primary caregivers reports on lifestyle behaviours of European pre-school children: the ToyBox-study. *Obes Rev* **15**, Suppl. 3, 61–66.
101. Manios Y, Androutsos O, Katsarou C *et al.* (2014) Designing and implementing a kindergarten-based, family-involved intervention to prevent obesity in early childhood: the ToyBox-study. *Obes Rev* **15**, Suppl. 3, 5–13.
102. Manios Y & ToyBox-study Group (2014) Methodological procedures followed in a kindergarten-based, family-involved intervention implemented in six European countries to prevent obesity in early childhood: the ToyBox-study. *Obes Rev* **15**, Suppl. 3, 1–4.
103. Moreno L, Mouratidou T, DeMiguel-Etayo P *et al.* (2013) Pre-school children's food intake and snacking habits and their determinants. *Ann Nutr Metab* **63**, 65–66.
104. Mouratidou T, Miguel ML, Androutsos O *et al.* (2014) Tools, harmonization and standardization procedures of the impact and outcome evaluation indices obtained during a kindergarten-based, family-involved intervention to prevent obesity in early childhood: the ToyBox-study. *Obes Rev* **15**, Suppl. 3, 53–60.
105. Payr A, Birnbaum J, Wildgruber A *et al.* (2014) Concepts and strategies on how to train and motivate teachers to implement a kindergarten-based, family-involved intervention to prevent obesity in early childhood. The ToyBox-study. *Obes Rev* **15**, Suppl. 3, 40–47.
106. Pil L, Putman K, Cardon G *et al.* (2014) Establishing a method to estimate the cost-effectiveness of a kindergarten-based, family-involved intervention to prevent obesity in early childhood. The ToyBox-study. *Obes Rev* **15**, Suppl. 3, 81–89.
107. Van Diepen S, Scholten AM, Korobili C *et al.* (2011) Greater Mediterranean diet adherence is observed in Dutch compared with Greek university students. *Nutr Metab Cardiovasc Dis* **21**, 534–540.
108. Evans AE, Ruidavets JB, McCrum EE *et al.* (1995) Autres pays, autres coeurs? Dietary patterns, risk factors and

Downloaded from http:/www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http:/www.cambridge.org/core/terms.
http://dx.doi.org/10.1017/S1368980016002366

ischaemic heart disease in Belfast and Toulouse. *QJM* **88**, 469–477.
109. Gerrits JH, O'Hara RE, Piko BF *et al.* (2010) Self-control, diet concerns and eater prototypes influence fatty foods consumption of adolescents in three countries. *Health Educ Res* **25**, 1031–1041.
110. Zaborskis A, Moceviciene R & Iannotti RJ (2014) The influence of chronological period of data collection on differences in reported dietary intake among school-aged children surveyed in 39 countries. *J Nutr Educ Behav* **46**, 359–369.
111. Diethelm K, Jankovic N, Moreno LA *et al.* (2012) Food intake of European adolescents in the light of different food-based dietary guidelines: results of the HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) Study. *Public Health Nutr* **15**, 386–398.
112. Vandevijvere S, Geelen A, Gonzalez-Gross M *et al.* (2013) Evaluation of food and nutrient intake assessment using concentration biomarkers in European adolescents from the Healthy Lifestyle in Europe by Nutrition in Adolescence study. *Br J Nutr* **109**, 736–747.
113. Larsson CL, Klock KS, Astrom AN *et al.* (2001) Food habits of young Swedish and Norwegian vegetarians and omnivores. *Public Health Nutr* **4**, 1005–1014.
114. Szczepanska E, Deka M & Calyniuk B (2013) Studies to determine nutrition behaviour amongst middle school pupils living in the border areas of Poland and the Czech Republic. *Rocz Panstw Zakl Hig* **64**, 191–196.
115. Stok FM, de Vet E, de Wit JB *et al.* (2015) The proof is in the eating: subjective peer norms are associated with adolescents' eating behaviour. *Public Health Nutr* **18**, 1044–1051.
116. Antova T, Pattenden S, Nikiforov B *et al.* (2003) Nutrition and respiratory health in children in six Central and Eastern European countries. *Thorax* **58**, 231–236.
117. Patterson E, Warnberg J, Kearney J *et al.* (2009) The tracking of dietary intakes of children and adolescents in Sweden over six years: the European Youth Heart Study. *Int J Behav Nutr Phys Act* **6**, 91.
118. Pala V, Lissner L, Hebestreit A *et al.* (2013) Dietary patterns and longitudinal change in body mass in European children: a follow-up study on the IDEFICS multicenter cohort. *Eur J Clin Nutr* **67**, 1042–1049.
119. Bornhorst C, Huybrechts I, Hebestreit A *et al.* (2013) Diet–obesity associations in children: approaches to counteract attenuation caused by misreporting. *Public Health Nutr* **16**, 256–266.
120. Nagel G, Weinmayr G, Kleiner A *et al.* (2010) Effect of diet on asthma and allergic sensitisation in the international study on allergies and asthma in childhood (ISAAC) phase two. *Thorax* **65**, 516–522.
121. Vereecken C, Covents M & Maes L (2010) Comparison of a food frequency questionnaire with an online dietary assessment tool for assessing preschool children's dietary intake. *J Hum Nutr Diet* **23**, 502–510.
122. Bel-Serrat S, Mouratidou T, Santaliestra-Pasias AM *et al.* (2013) Clustering of multiple lifestyle behaviours and its association to cardiovascular risk factors in children: the IDEFICS study. *Eur J Clin Nutr* **67**, 848–854.
123. Haveman-Nies A, De Groot LCPGM & Van Staveren WA (1998) Snack patterns of older Europeans. *J Am Diet Assoc* **98**, 1297–1302.
124. Martin-Moreno JM, Boyle P, Gorgojo L *et al.* (1993) Development and validation of a food frequency questionnaire in Spain. *Int J Epidemiol* **22**, 512–519.
125. Bohlscheid-Thomas S, Hoting I, Boeing H *et al.* (1997) Reproducibility and relative validity of food group intake in a food frequency questionnaire developed for the German part of the EPIC project. European Prospective Investigation into Cancer and Nutrition. *Int J Epidemiol* **26**, Suppl. 1, S59–S70.
126. Brunner E, Stallone D, Juneja M *et al.* (2001) Dietary assessment in Whitehall II: comparison of 7 d diet diary and food-frequency questionnaire and validity against biomarkers. *Br J Nutr* **86**, 405–414.
127. Willett WC, Sampson L, Stampfer MJ *et al.* (1985) Reproducibility and validity of a semiquantitative food frequency questionnaire. *Am J Epidemiol* **122**, 51–65.
128. Goldbohm RA, van den Brandt PA, Brants HA *et al.* (1994) Validation of a dietary questionnaire used in a large-scale prospective cohort study on diet and cancer. *Eur J Clin Nutr* **48**, 253–265.
129. Brinkman MT, Kellen E, Zeegers MP *et al.* (2011) Validation of the IMMIDIET food frequency questionnaire in an adult Belgian population: a report from the Belgian case–control study on bladder cancer risk. *Acta Clin Belg* **66**, 18–25.
130. Kristjansdottir AG, Andersen LF, Haraldsdottir J *et al.* (2006) Validity of a questionnaire to assess fruit and vegetable intake in adults. *Eur J Clin Nutr* **60**, 408–415.
131. Bloemberg BP, Kromhout D, Obermann-De Boer GL *et al.* (1989) The reproducibility of dietary intake data assessed with the cross-check dietary history method. *Am J Epidemiol* **130**, 1047–1056.
132. Vereecken CA & Maes L (2003) A Belgian study on the reliability and relative validity of the Health Behaviour in School-Aged Children food-frequency questionnaire. *Public Health Nutr* **6**, 581–588.
133. Singh AS, Vik FN, Chinapaw MJM *et al.* (2011) Test–retest reliability and construct validity of the ENERGY-child questionnaire on energy balance-related behaviours and their potential determinants: the ENERGY-project. *Int J Behav Nutr Phys Act* **8**, 136.
134. Bornhorst C, Bel-Serrat S, Pigeot I *et al.* (2014) Validity of 24-h recalls in (pre-)school aged children: comparison of proxy-reported energy intakes with measured energy expenditure. *Clin Nutr* **33**, 79–84.
135. Bel-Serrat S, Fernandez Alvira JM, Pala V *et al.* (2011) Relative validation of two dietary assessment methods: SACINA (24-h recall) and food frequency questionnaire. In 1st IDEFICS Symposium and Workshop Child Health in Europe – The IDEFICS Study: Towards a Better Understanding of Obesity; 2010, Nov 8–9; Zaragoza, Spain. *Int J Obes (Lond)* **35**, Suppl. 1, S152 (abstract).
136. de Bourdeaudhuij I, Klepp KI, Due P *et al.* (2005) Reliability and validity of a questionnaire to measure personal, social and environmental correlates of fruit and vegetable intake in 10–11-year-old children in five European countries. *Public Health Nutr* **8**, 189–200.
137. Huybrechts I, De Backer G, De Bacquer D *et al.* (2009) Relative validity and reproducibility of a food-frequency questionnaire for estimating food intakes among Flemish preschoolers. *Int J Environ Res Public Health* **6**, 382–399.
138. Tyrovolas S, Pounis G, Bountziouka V *et al.* (2010) Repeatability and validation of a short, semi-quantitative food frequency questionnaire designed for older adults living in Mediterranean areas: the MEDIS-FFQ. *J Nutr Elder* **29**, 311–324.
139. Bel-Serrat S, Mouratidou T, Bornhorst C *et al.* (2013) Food consumption and cardiovascular risk factors in European children: the IDEFICS study. *Pediatr Obes* **8**, 225–236.
140. Huybrechts I, Bornhorst C, Pala V *et al.* (2011) Evaluation of the Children's Eating Habits Questionnaire used in the IDEFICS study by relating urinary calcium and potassium to milk consumption frequencies among European children. *Int J Obes (Lond)* **35**, Suppl. 1, S69–S78.
141. Bingham SA, Gill C, Welch A *et al.* (1997) Validation of dietary assessment methods in the UK arm of EPIC using weighed records, and 24-hour urinary nitrogen and potassium and serum vitamin C and carotenoids as biomarkers. *Int J Epidemiol* **26**, Suppl. 1, S137–S151.

Downloaded from http:/www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http:/www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366

142. Steptoe A & Wardle J (1996) The European Health and Behaviour Survey: the development of an international study in health psychology. *Psychol Health* **11**, 49–73.
143. Pisani P, Faggiano F, Krogh V *et al.* (1997) Relative validity and reproducibility of a food frequency dietary questionnaire for use in the Italian EPIC centres. *Int J Epidemiol* **26**, Suppl. 1, S152–S160.
144. Lytle LA, Nichaman MZ, Obarzanek E *et al.* (1993) Validation of 24-hour recalls assisted by food records in third-grade children. The CATCH Collaborative Group. *J Am Diet Assoc* **93**, 1431–1436.
145. Lanfer A, Hebestreit A, Ahrens W *et al.* (2011) Reproducibility of food consumption frequencies derived from the Children's Eating Habits Questionnaire used in the IDEFICS study. *Int J Obes (Lond)* **35**, Suppl. 1, S61–S68.
146. Paalanen L, Prattala R, Palosuo H *et al.* (2011) Socioeconomic differences in the consumption of vegetables, fruit and berries in Russian and Finnish Karelia: 1992–2007. *Eur J Public Health* **21**, 35–42.
147. Boylan S, Lallukka T, Lahelma E *et al.* (2011) Socioeconomic circumstances and food habits in Eastern, Central and Western European populations. *Public Health Nutr* **14**, 678–687.
148. de Groot LC, Verheijden MW, de Henauw S *et al.* (2004) Lifestyle, nutritional status, health, and mortality in elderly people across Europe: a review of the longitudinal results of the SENECA study. *J Gerontol A Biol Sci Med Sci* **59**, 1277–1284.
149. van Staveren WA, de Groot LC, Burema J *et al.* (1995) Energy balance and health in SENECA participants. Survey in Europe on Nutrition and the Elderly, a Concerted Action. *Proc Nutr Soc* **54**, 617–629.
150. Peasey A, Bobak M, Kubinova R *et al.* (2006) Determinants of cardiovascular disease and other non-communicable diseases in Central and Eastern Europe: rationale and design of the HAPIEE study. *BMC Public Health* **6**, 255.
151. Cook LT, O'Reilly GA, Derosa CJ *et al.* (2015) Association between home availability and vegetable consumption in youth: a review. *Public Health Nutr* **18**, 640–648.
152. Cade J, Thompson R, Burley V *et al.* (2002) Development, validation and utilisation of food-frequency questionnaires – a review. *Public Health Nutr* **5**, 567–587.
153. Thompson FE & Subar AF (2001) Dietary assessment methodology. In *Nutrition in the Prevention and Treatment of Disease*, pp. 3–30 [M Ferruzzi, AM Coulston and C Boushy, editors]. San Diego, CA: Academic Press.
154. National Cancer Institute (2016) Dietary Assessment Research Resources. http://epi.grants.cancer.gov/dietary-assessment/resources.html#methods (accessed August 2016).
155. Wrieden W, Peace H, Armstrong J *et al.* (2003) A short review of dietary assessment methods used in national and Scottish research studies. Briefing Paper prepared for the *Working Group on Monitoring Scottish Dietary Targets Workshop*, September 2003.
156. Serra-Majem L, Frost Andersen L, Henrique-Sanchez P *et al.* (2009) Evaluating the quality of dietary intake validation studies. *Br J Nutr* **102**, Suppl. 1, S3–S9.
157. Shim J-S, Oh K & Kim HC (2014) Dietary assessment methods in epidemiologic studies. *Epidemiol Health* **36**, e2014009.
158. Centers for Disease Control and Prevention (2016) National Health and Nutrition Survey (NHANES). http://www.cdc.gov/nchs/nhanes/ (accessed July 2016).

Public Health Nutrition

Downloaded from http:/www.cambridge.org/core. University College Cork, on 04 Oct 2016 at 15:31:13, subject to the Cambridge Core terms of use, available at http:/www.cambridge.org/core/terms. http://dx.doi.org/10.1017/S1368980016002366