#### **ORIGINAL CONTRIBUTION**



# Description of the updated nutrition calculation of the Oxford WebQ questionnaire and comparison with the previous version among 207,144 participants in UK Biobank

Aurora Perez-Cornago<sup>1</sup> · Zoe Pollard<sup>1</sup> · Heather Young<sup>1</sup> · Marloes van Uden<sup>2</sup> · Colm Andrews<sup>1</sup> · Carmen Piernas<sup>3</sup> · Timothy J. Key<sup>1</sup> · Angela Mulligan<sup>2,4</sup> · Marleen Lentjes<sup>2,5</sup>

Received: 10 December 2020 / Accepted: 3 April 2021 / Published online: 6 May 2021 © The Author(s) 2021

#### Abstract

**Purpose** The Oxford WebQ is a web-based 24-h dietary assessment method which has been used in UK Biobank and other large prospective studies. The food composition table used to calculate nutrient intakes has recently been replaced with the UK Nutrient Databank, which has food composition data closer in time to when participants completed the questionnaire, and new dietary variables were incorporated. Here we describe the updated version of the Oxford WebQ questionnaire nutrient calculation, and compare nutrient intakes with the previous version used.

**Methods** 207,144 UK Biobank participants completed  $\geq$  1 Oxford WebQs, and means and standard deviations of nutrient intakes were averaged for all completed 24-h dietary assessments. Spearman correlations and weighted kappa statistics were used to compare the re-classification and agreement of nutrient intakes between the two versions.

**Results** 35 new nutrients were incorporated in the updated version. Compared to the previous version, most nutrients were very similar in the updated version except for a few nutrients which showed a difference of > 10%: lower with the new version for trans-fat (-20%), and vitamin C (-15%), but higher for retinol (+42%), vitamin D (+26%) and vitamin E (+20%). Most participants were in the same (>60%) or adjacent (>90%) quintile of intake for the two versions. Except for trans-fat (r=0.58,  $\kappa=0.42$ ), very high correlations were found between the nutrients calculated using the two versions (r>0.79 and  $\kappa>0.60$ ). **Conclusion** Small absolute differences in nutrient intakes were observed between the two versions, and the ranking of individuals was minimally affected, except for trans-fat.

Keywords Online 24-h dietary assessment · Oxford WebQ · UK Biobank · Comparative study · Food composition table

Angela Mulligan and Marleen Lentjes have contributed equally.

Aurora Perez-Cornago aurora.perez-cornago@ndph.ox.ac.uk

<sup>1</sup> Cancer Epidemiology Unit, Nuffield Department of Population Health, University of Oxford, Richard Doll Building, Roosevelt Drive, Oxford OX3 7LF, UK

- <sup>2</sup> Department of Public Health & Primary Care, Institute of Public Health, University of Cambridge, Cambridge, UK
- <sup>3</sup> Nuffield Department of Primary Care Health Sciences, University of Oxford, Oxford, UK
- <sup>4</sup> NIHR BRC Diet, Anthropometry and Physical Activity Group, MRC Epidemiology Unit, University of Cambridge, Cambridge, UK
- <sup>5</sup> School of Medical Sciences, Clinical Epidemiology and Biostatistics, Örebro University, Örebro, Sweden

# Introduction

Traditional methods to determine dietary intake in large prospective studies, such us paper-based food frequency questionnaires (FFQ) and/or interviewer administered 24-h recalls, are costly and time-consuming. Recently, selfadministered online 24-h dietary assessments have been incorporated in some large prospective studies and been shown to facilitate data analyses and decrease the researcher burden, including data entry and data coding, by automatically calculating nutrient intakes [1].

The Oxford WebQ is a fully automated web-based 24-h dietary assessment tool which seeks information from participants about their consumption of food and drink during the previous 24 h [2]. This online questionnaire has already been used by several large-scale cohort studies, such us the UK Biobank [3] and the Million Women Study [4], as it is easy and quick (~12 min) to self-complete and suitable for repeated use in large-scale prospective studies. Moreover, nutrients are automatically estimated via built-in algorithms and food composition data. Until now, the food composition table (FCT) used for the Oxford WebQ has been the UK McCance and Widdowson's "The Composition of Foods 6th edition (2002) and its supplements [5-15], of which 550 of 1200 foods were incorporated into the Oxford WebQ. This FCT has now been replaced by the UK Nutrient Databank (UKNDB) (2013), which provides food composition data measured closer in time to when participants completed the questionnaire in UK Biobank (2009-2012) and contains over 5600 foods, of which 681 food codes have been incorporated into the Oxford WebQ [16, 17]. The UKNDB is commissioned by Public Health England as part of the National Diet and Nutrition Survey (NDNS), and is available in electronic format as an integrated dataset, and contains up-to-date nutrient composition data. Data in the UKNDB are very similar to the UK McCance and Widdowson's FCT but includes a larger range of processed foods and composite dishes and missing values were reviewed and replaced with plausible values and it is maintained as part of NDNS. As well as replacing the FCT used to calculate nutrient intakes, we have made other changes such as some changes in portion sizes, personalisation of fats used in cooking, and updating the underlying program code for the nutrient calculation, and new dietary variables such as energy density, and animal and plant fats and proteins, have been incorporated. This paper describes the main changes made to nutrient estimation for the Oxford WebQ questionnaire, and compares the two versions of obtained nutrient intakes in over 200,000 UK Biobank participants.

# Methods

# **Study design**

UK Biobank includes a total of 211,031 participants aged 40–69 years who have completed the Oxford WebQ dietary assessment at least once between 2009 and 2012. Details about the UK Biobank study can be found elsewhere [3]. Briefly, participants provided detailed information on a range of sociodemographic, physical, lifestyle, and health-related factors via self-completed touch-screen questionnaires and a computer-assisted personal interview at recruitment [3].

The study protocol and information about data access are available online (http://www.ukbiobank.ac.uk/wp-content/uploads/2011/11/UK-Biobank-Protocol.pdf) and in the literature [18].

# Dietary assessment—the Oxford WebQ questionnaire

The Oxford WebQ questionnaire was developed to obtain information on the quantities of up to 206 types of foods and 32 types of drinks consumed over the previous day (24 h; https://biobank.ctsu.ox.ac.uk/crystal/crystal/docs/ DietWebQ.pdf) [2]. The quantity of each food or drink consumed is calculated by multiplying the assigned portion size (Supplementary Table 1) of each food or beverage by the amount consumed [19]. This questionnaire has recently been validated; compared to recovery biomarkers for energy, protein and potassium, and was considered to perform well in approximating true dietary intake [20]. This questionnaire also provided similar mean estimates of energy and nutrient intakes when compared with an interviewer administered 24-h dietary recall [2]. Further information about the Oxford WebQ can be found here https://www.ceu.ox.ac.uk/research/oxford-webq.

For the previous version of calculating nutrient intakes for the Oxford WebQ, the UK McCance and Widdowson's 6th edition (2002) FCT and its supplements were used [2]. The nutrients determined were total energy intake, total protein, total fat, saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), cholesterol, carbohydrates, total sugars, fibre, alcohol, calcium, iron, magnesium, potassium, carotene, vitamin B6, vitamin B12, vitamin C, vitamin D and vitamin E. Details about the nutrient calculation can be found in Supplementary Table 2. Trans fatty acids (TFA) and retinol in the previous version of the nutrient calculation were excluded since there were multiple food codes with missing values; for the purpose of comparison, illustration of the consequences of missing data, and because TFA have a public health impact, we are however presenting the results from the previous calculation here.

For the updated version of the nutrient calculation of the Oxford WebQ, nutrient intakes were calculated using the UKNDB FCT from survey year 6, which includes FCT for years 2012-2013 and 2013-2014. Moreover, changes in allocated portion sizes, personalisation of milk types and fats used in cooking, gluten-free versions and the underlying code for nutrient calculation were revised and updated (details in Table 1 and Supplementary Tables 2, 3). Except for total PUFA, all the nutrients available in the previous version are also available in the UKNDB (and total PUFA can be calculated by adding n-3 and n-6 PUFA). Moreover, the following further dietary variables are now available: energy density, animal protein, plant protein, animal fat, plant fat, MUFA, n-3 PUFA, n-6 PUFA, free sugars, nonfree sugars, non-milk extrinsic sugars, intrinsic and milk sugars, fructose, glucose, sucrose, lactose, maltose, other

Table 1 Major changes between the previous (McCance and Widdowson) version and the updated (Nutrient databank + other changes) version

| Item                                      | Changes made to the updated version (Nutrient databank + other changes)  |
|---|--|
| Portion size                              | Some food items had their serving size changed to better reflect what an average portion size would be, taking into account how the question was asked (e.g. Yorkshire pudding). Some portion sizes were revised based on published data (e.g. spreads). Some portion sizes were changed to reflect the state of the food item (e.g. edible part of fruit, or inclusion of liquid for powdered items). These changes can be found in Supplementary Table 1                           |
| Milk type                                 | We have now taken into account each milk type beyond fat content, including cholesterol lowering milk, goat's or sheep's milk, powdered milk, rice, oat, almond, coconut milk, fortified soya milk, unfortified soya milk, other milk (e.g. lactose free) as well as skimmed, semi skimmed and whole milk<br>This is now applied to all hot drinks where milk is added (i.e. tea, coffee, cappuccino, latte, hot chocolate), milk-based sauces, porridge, crepes and pancakes/blinis |
| Type of fat used in<br>cooking vegetables | Participants were asked to select the type of fat/oil, if any, they use in the cooking, and a total 40 different types of fat/oils were available. We have now added an amount of fat/oils in certain vegetables such as onion, mushroom, mixed veg, peppers, courgette, leek, parsnip, veg other and mashed potato which are likely to be cooked with oils/fats. These fats/ oils include:  |
|   | Butters, spreadable butters, hard margarine, lard, dairy spreads, polyunsaturated margarines, cholesterol lowering marga-<br>rines, olive oil-based spreads, soya spreads, olive oil, rapeseed oil, sunflower oil, vegetable oil   |
| Gluten-free versions                      | We have added a gluten-free version where available (e.g. for baguettes, bread rolls, sliced bread, and pasta)   |
| Powdered milk                             | A water code was added to powdered milk codes so the food volume fits with the way the food is served (important in relation to e.g. energy density)   |
| 'Other' items                             | We studied the free text entered by the UK Biobank participants and where possible mapped the 'other' items against commonly entered foods (i.e. according to the participants' understanding of the questions). Whereas previously, these were mapped against a more generic item or a selection of items which were truly different from the specific items listed due to lack of a suitable food code   |

Further details about these changes can be found in Supplementary Table 1

sugars, alpha-carotene, beta-carotene, beta cryptoxanthin, vitamin a (retinol equivalents), biotin, chloride, copper, haem iron, non-haem iron, iodine, manganese, sodium, niacin equivalent, pantothenic acid, selenium, total nitrogen and zinc.

# Updated nutrient calculation in the Oxford WebQ questionnaire

#### Step 1: Selection of UK Nutrient Databank

The 7th edition of the McCance and Widdowson's Composition of Foods (abbreviated with CoF) and the UK Nutrient Databank FCT (UKNDB) were considered as possible replacements of the previous FCT. We decided to use the UK Nutrient Databank because missing values were reviewed and replaced with plausible values and it is maintained as part of the National Diet and Nutrition Survey and is updated annually. We used the FCT from survey year 6 as it includes the food composition tables for years 2012–2013 and 2013–2014 [16].

#### Step 2: Changes in the nutrient calculation

Together with changing all the food codes to equivalent food codes from the UKNDB, we reviewed all the portion sizes and took into account the milk type, fats for cooking vegetables, and gluten-free foods in this updated version. Food codes: We incorporated food codes that better reflected the WebQ item reported by the participants by looking at how each question was asked in the Oxford WebQ questionnaire. Each WebQ item resulted in up to 11 different food codes, with percentages being assigned to each food code (e.g. the food codes used for grapes are 50% black/red grapes and 50% green grapes; see Supplementary Table 2 for details). Unless the WebQ item was specified to be fortified, non-fortified food items were selected. Non-specific answer choices are now mapped to food items reflecting the most likely food choices in the UK biobank population.

Portion sizes: All the portion sizes were revised and updated if required. For this, we took into account how each question was asked to try to understand what the participant may have understood a portion size was, and we also used UK standard portion sizes [19] and product information on packaging from different UK online supermarkets. The changes in portion sizes can be found in Supplementary Table 1.

Milk type: Participants were asked "which type of milk did you use most frequently yesterday?" We have taken into account each milk type including cholesterol lowering milk, goat's or sheep's milk, powdered milk, rice, oat, almond, coconut milk, fortified soya milk, unfortified soya milk, other milk (e.g. lactose free) as well as skimmed, semi skimmed and whole milk. We incorporated this into tea, different types of coffee, hot chocolate, milk based sauces, porridge, crepes and pancakes/blinis. A small amount of water was added to the WebQ item of coffee latte and cappuccino to account for the foam in these types of coffees.

Personalisation of fats used in cooking vegetables: Participants were asked "which types of butter, margarine or oil, were used in cooking your food yesterday?" We have taken into account the 40 different types of fat/oils used in the cooking where available and added an amount of fat/ oils to certain vegetables: onions, mushrooms, miscellaneous vegetable pieces, peppers, courgette, leek, parsnip, other/unspecified vegetables and mashed potato which are likely to be cooked with oils/fats. These fats/oils include: Butters, spreadable butters, hard margarine, lard, dairy spreads, polyunsaturated margarines, cholesterol lowering margarines, olive oil-based spreads, soya spreads, olive oil, rapeseed oil, sunflower oil, and vegetable oil.

Gluten-free versions: Participants were asked whether they follow a special diet, and this included gluten-free diets. We have added a gluten-free version where available (e.g. for baguettes, bread rolls, large baps, sliced bread, sweet biscuits, scones, pasta). Supplementary Table 1 indicates for which food codes this was not available, and, therefore, the nutrients are the same as the gluten version.

Powdered milk in cereal, and in a glass: A water code has been added to these dried food codes to be "made up" and to account for food volume fitting in better with the portion sizes.

#### Step 3: New dietary variables

Energy density: Energy density was calculated for all foods except beverages by dividing total food energy (kJ) by total food weight (g) [21].

Animal and plant protein: The amount of animal and plant protein in each food item was determined examining the food sources.

Animal and plant fat: The amount of animal and plant fat in each food item was determined examining the food sources.

Free sugars: Foods and drinks were classified as containing free sugars (all monosaccharides and disaccharides added to foods by the manufacturer, cook or consumer, plus sugars naturally present in honey, syrups and unsweetened fruit juices) based on the Scientific Advisory Committee on Nutrition (SACN) in the UK definitions [22].

Non-free sugars: Non-free sugars were calculated as the difference between total sugars and free sugars.

Other dietary variables: 24 dietary variables available in the Nutrient databank resource were incorporated (full list of nutrients in Table 4).

#### European Journal of Nutrition (2021) 60:4019-4030

#### Step 4: Output and calculation of nutrient intakes

Nutrient intakes per 100 g were calculated for each food item in the questionnaire (Supplementary Table 2). The following assumptions were made when calculating nutrient intakes:

For unanswered questions, it was assumed that the participant did not consume that food.

For spread on bread:

- If no thickness was selected, medium was assumed.
- Participants are required to select at least one spread type. If multiple are selected, then equal proportions from the portion size selected are assigned (e.g. 1 portion of spread in baguette, 50% to butter spreadable and 50% to margarine).
- If no spread sub options were selected (for those spreads with sub options), "don't know" was assumed.

Like the spreads, other items with multiple sub options (such as glass size for wine, ingredient type in soup, flour type for bread), were given an equal proportion per sub option (e.g. 2 bowls of soup with meat and vegetable ingredients selected, then that would be treated as 1 bowl of meat soup and 1 bowl of vegetable soup).

For meat: for most meat questions, there is a compulsory question about removing the fat. If "don't know" or "varied" were selected, then half the number of servings were assigned to codes of meat with fat not removed, and half of serving were assigned to codes of meat with fat removed.

Similarly for chicken/turkey, there is a compulsory question about removing the skin. If "don't know" or "varied" were selected, then half the number of servings were assigned to codes of poultry with skin left on, and half of serving were assigned to codes of poultry with skin removed.

For items that included a question on sugar (cereal, tea and coffee), if "varied" was selected, then 1tsp of sugar was assumed.

For breakfast cereals, the following questions is asked "Did your cereal contain any dried fruit?" If "varied" is selected, then half the number of servings were assigned to codes of breakfast cereals with dried fruit, and half of serving were assigned to codes of breakfast cereals without dried fruit.

Similarly, for other items in which "varied" was an option (i.e. decaf status for black tea/coffee, whether milk was added to cereal, tea or coffee), varied was treated as half with and half without.

For wine, if no glass size was selected, medium was assumed.

For porridge, if neither "made with milk" nor "made with water" were selected, then it was handled as half milk and half water.

Similarly for yogurt, if neither "full fat" nor "low fat" were selected, then it was handled as half full fat and half low fat yogurt.

#### **Quality assessment**

Five researchers were involved in the quality assessment. The first version of the matching of the foods in the questionnaire with the food codes in the UKNDB and the updated version of the portion sizes was done separately by two researchers (AM, ML), and inconsistencies were discussed; MU also contributed to this initial update. A third researcher (APC) reviewed all the food matching and portion sizes, suggested changes to the portion sizes, food codes, and fractions assigned to each food code, and further modifications were made after discussion with the other researchers (AM, ML, APC, HY). Each food item in the nutrient calculation file was comprehensively checked, and the amounts of each nutrient within each food item was compared with the amounts in the previous version of the nutrient calculation file (ZP, APC; Supplementary Table 3). Where more than 10% difference in nutrient intakes were found, these food codes were further reviewed and discussed with the other researchers, explanations for these changes were found, and where necessary the food codes or portion sizes were changed. HY helped with the overall quality check of this updated version, reviewing it, incorporating it into the database and identifying problems such as detecting the fractions of each food code that did not add up to 100% or verifying that the food codes selected did not have any missing nutrient values. After all these quality controls, APC, ZP, AM, and ML reviewed independently the final version of the nutrient calculation file (Supplementary Tables 1 and 2).

The new variables (energy density, animal and plant protein, animal and plant fat, free sugars, and non-free sugars) were determined separately by APC, ZP and CP, inconsistencies were discussed and the necessary changes were made.

#### **Participants**

A subsample of UK Biobank participants recruited towards the end of the recruitment period (from April 2009 to September 2010) was invited to complete the Oxford WebQ questionnaire. Moreover, those who provided email addresses were invited to complete the Oxford WebQ a total of four times every 3–4 months on variable days of the week during the follow-up period (online cycle 1, February 2011 to April 2011; online cycle 2, June 2011 to September 2011; online cycle 3, October 2011 to December 2011; online cycle 4, April 2012 to June 2012). 24-h dietary assessments with extreme energy intakes (men: < 3347 or > 17,573 kJ/ days or < 800 or > 4200 kcal/days); women: < 2092 or > 14,644 kJ/days or < 600 or > 3500 kcal/days) [23] as calculated with either version of the FCT, were excluded. For this reason, 3887 participants were excluded because they did not have a valid WebQ. In this analysis, we are not interested in usual intakes for individuals but in comparing the estimates of intakes of the participants in the completed 24-h dietary assessments; therefore, we have not excluded participants with only one dietary assessment. However, researchers using this dietary assessment tool for diet–disease associations are advised to use at least two 24-h dietary assessments(but more if possible), since intakes from one 24-h dietary assessment are unlikely to reflect usual intakes[20]. A total of 207,144 (out of 211,031, 98%) participants were included in this study.

#### **Statistical analyses**

The WebQ results were averaged for all completed 24-h dietary questionnaire for each participant. Means, standard deviations (SDs), and the 5th and 95th percentiles of nutrient intakes are given. The differences and percentage difference (see equation) in nutrient intakes between the previous and the updated version of the nutrient calculation were determined, and means were compared using paired t tests or Wilcoxon's rank sum test, depending on the normality of the distribution.

% difference = 
$$\frac{(\text{updated} - \text{previous})}{\text{previous}} \times 100\%$$

The Spearman correlations of the nutrient data were calculated. Participants were divided into fifths of intake for each nutrient in the two versions of the nutrient calculation and weighted kappa statistics and the percentage of participants who were categorised into the same or adjacent fifth were calculated, since most prospective studies on diet and disease risk examine associations by comparing disease incidence in categories of the dietary factor of interest. Weighted kappas should be interpreted as follows: values  $\leq 0$  indicates no agreement, 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41–0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement [24].

All analyses were conducted using the STATA statistical software package version 14 (Stata Corporation, College Station, TX, USA).

# Results

The mean age at recruitment was 56 years (SD 8) and 55% were women. Participants completed on average 2.14 (SD 1.16) 24-h dietary assessments. Table 2 shows the mean, median, percentiles, and mean differences of energy and nutrient intakes in the two versions. There were small but

| its from             |         |
|----------------------|---------|
| participan           |         |
| 207,144 <sub>1</sub> |         |
| ources in            |         |
| es) datas            |         |
| ther updat           |         |
| abank + o            |         |
| trient dat           |         |
| dated (Nu            |         |
| on) and up           |         |
| Widdowsc             |         |
| ance and V           |         |
| ous (McCa            |         |
| ween previc          |         |
| take betwe           |         |
| d nutrient int       |         |
| rgy an               |         |
| f total ene          |         |
| iparison of          |         |
| <b>able 2</b> Com    | Biobank |
| Tabl                 | UK B    |

| Mean (SD)                             |            |        |                |                 |              |        | r.             |                 |         |                                      |
|---------------------------------------|------------|--------|----------------|-----------------|--------------|--------|----------------|-----------------|---------|--------------------------------------|
|                                       | (SD)       | Median | 5th percentile | 95th percentile | Mean (SD)    | Median | 5th percentile | 95th percentile |         | Percentage<br>change, % <sup>b</sup> |
| Energy (kJ/day) 8675 (2238)           | 2238)      | 8479   | 5311           | 12,708          | 8547 (2204)  | 8350   | 5250           | 12,519          | - 128.6 | - 1.48                               |
| Protein (g/day) 81.3 (23.3)           | 13.3)      | 79.6   | 46.4           | 121.3           | 80.1 (22.9)  | 78.30  | 46.07          | 119.72          | - 1.18  | - 1.45                               |
| Total fat (g/day) 76.5 (27.5)         | 27.5)      | 73.7   | 36.6           | 126.0           | 72.1 (26.3)  | 69.27  | 34.27          | 119.49          | -4.38   | -5.72                                |
|                                       | 1.7)       | 27.8   | 12.7           | 50.7            | 26.7 (11.2)  | 25.22  | 11.03          | 47.19           | -2.57   | -8.80                                |
| PUFA (g/day) <sup>c</sup> 14.1 (6.88) | 6.88)      | 13.1   | 5.1            | 26.8            | 12.7 (5.488) | 11.94  | 5.43           | 22.80           | - 1.39  | -10.37                               |
| TFA (g/day) 1.47 (0.794)              | .794)      | 1.34   | 0.43           | 2.93            | 1.20 (0.649) | 1.08   | 0.34           | 2.36            | - 0.29  | - 19.8                               |
| Carbohydrates (g/day) 249 (74.4)      | 4.4)       | 243    | 139            | 381             | 252 (72.7)   | 246    | 143.30         | 380.44          | 2.45    | 0.98                                 |
| Total sugars (g/day) 119 (45.5)       | 5.5)       | 113    | 54             | 201             | 124 (46.3)   | 119    | 58.32          | 207.25          | 5.44    | 4.59                                 |
| Englyst fibre (g/day) 16.3 (6.34)     | (34)       | 15.6   | 7.3            | 27.5            | 17.7 (6.40)  | 17.11  | 8.44           | 28.98           | 1.42    | 8.70                                 |
| Alcohol (g/day) 16.1 (21.0)           | (11.0)     | 8.7    | 0.0            | 58.5            | 16.9 (21.7)  | 9.05   | 0.00           | 59.91           | 0.74    | 4.62                                 |
| Calcium (mg/day) 959 (329)            | 29)        | 923    | 492            | 1545            | 975 (325)    | 942    | 509            | 1550            | 16.33   | 1.70                                 |
| Iron (mg/day) 13.6 (4.14)             | 14)        | 13.2   | 7.3            | 20.8            | 12.3 (3.60)  | 11.98  | 6.85           | 18.55           | - 1.29  | -9.55                                |
| Magnesium (mg/day) 343 (95.5)         | 5.5)       | 335    | 203            | 513             | 330 (88.4)   | 323    | 199            | 486             | - 13.03 | -3.80                                |
| Potassium (mg/day) 3695 (1064)        | 1064)      | 3609   | 2121           | 5553            | 3640 (1007)  | 3571   | 2115           | 5384            | -55.20  | - 1.49                               |
| Total carotene (µg/day) 3091 (2583)   | 2583)      | 2522   | 316            | 7876            | 2959 (2791)  | 2095   | 334            | 8063            | - 131.8 | -4.26                                |
| Folate (µg/day) 301 (107.2)           | 07.2)      | 287    | 152            | 496             | 310 (104)    | 300    | 160            | 493             | 9.79    | 3.26                                 |
| Vitamin B6 (mg/day) 2.16 (0.691)      | .691)      | 2.11   | 1.13           | 3.36            | 2.05 (0.664) | 1.99   | 1.09           | 3.23            | -0.11   | -5.07                                |
| Vitamin B12 (μg/day) 6.47 (4.49)      | (64)       | 5.39   | 1.64           | 14.90           | 6.11 (3.25)  | 5.56   | 2.21           | 11.66           | -0.36   | -5.61                                |
| Vitamin C (mg/day) 150 (102)          | <b>)2)</b> | 131    | 30             | 338             | 127 (76.5)   | 115    | 29             | 266             | -23.35  | -15.53                               |
| Vitamin D (μg/day) 2.85 (2.71)        | .71)       | 2.02   | 0.34           | 8.92            | 3.60 (2.866) | 2.83   | 0.66           | 9.45            | 0.75    | 26.24                                |
| Vitamin E (mg/day) 9.01 (3.98)        | (86)       | 8.47   | 3.60           | 16.27           | 10.8 (4.26)  | 10.30  | 4.85           | 18.54           | 1.80    | 19.99                                |
| Retinol (µg/day) 323 (169)            | (65        | 300    | 89             | 641             | 461 (884)    | 305    | 89             | 880             | 137.2   | 42.0                                 |

<sup>b</sup>Calculated as the difference of the mean (UK Nutrient Databank—McCance and Widdowson) divided by McCance and Widdowson and multiplied by 100

°For the Nutrient databank this is the sum of n-3 and n-6 PUFAs

significant differences (likely due to the large sample size) in the mean nutrient intakes between the existing version and the updated version. Compared to the previous version, intakes in the updated version were > 10% different for the following nutrients: lower for TFA (-20%), vitamin C (-15%) and iron (-9.5%), but higher for retinol (+42%), vitamin D (+26%) and vitamin E (+20%). SFA and TFA intakes provided 12.4% and 0.63% from total energy intake in the previous version of the nutrient calculation, while they provided 11.6% and 0.52% respectively in the updated version.

A total of 35 new nutrients and exposures of interest were available in the UKNDB, and intakes of these nutrients in this population are displayed in Table 3.

Table 4 shows the correlations and the strengths of agreement on ranking nutrient intakes between the previous and

| Table 3New nutrientsincorporated in the  | Nutrient                                 | Updated version: Nutrient databank + other updates |        |                |                 |
|--|--|--|--------|----------------|-----------------|
| updated version (Nutrient<br>databank + other updates) data<br>source in 207,144 participants<br>from UK Biobank |  | Mean (SD)  | Median | 5th percentile | 95th percentile |
|  | Energy density (kJ/g per day)*           | 6.47 (1.67)  | 6.28   | 4.10           | 9.45            |
|  | Animal protein (g/day)*                  | 52.1 (20.6)  | 51.00  | 20.55          | 87.00           |
|  | Plant protein (g/day)*                   | 28.0 (9.84)  | 26.78  | 14.42          | 45.56           |
|  | Animal fat (g/day)*                      | 40.4 (18.7)  | 37.89  | 14.63          | 74.62           |
|  | Plant fat (g/day)*                       | 31.7 (15.3)  | 29.45  | 11.30          | 59.78           |
|  | MUFA (g/day)                             | 26.1 (10.2)  | 24.92  | 11.74          | 44.55           |
|  | n-3 PUFA (g/day)                         | 1.97 (0.966)                                       | 1.79   | 0.77           | 3.75            |
|  | n–6 PUFA (g/day)                         | 10.80 (4.86)                                       | 10.02  | 4.41           | 19.70           |
|  | Free sugar (% daily energy intake)       | 11.8 (5.8)   | 11     | 3.7            | 22.1            |
|  | Free sugars (g/day)*                     | 60.0 (34.7)  | 54.31  | 15.09          | 123.73          |
|  | Non-free sugars (g/day)*                 | 63.9 (30.3)  | 59.99  | 22.70          | 118.40          |
|  | Non-milk extrinsic sugars (g/day)        | 64 (35)  | 59     | 18             | 128             |
|  | Intrinsic and milk sugars (g/day)        | 60 (27)  | 57     | 22             | 108             |
|  | Fructose (g/day)                         | 28 (14)  | 26     | 8.33           | 53              |
|  | Glucose (g/day)                          | 26 (13)  | 25     | 8.96           | 49              |
|  | Sucrose (g/day)                          | 47 (24)  | 43     | 16             | 91              |
|  | Lactose (g/day)                          | 14 (8)   | 13     | 2.68           | 27              |
|  | Maltose (g/day)                          | 6.67 (6.85)  | 4.69   | 1.15           | 20.17           |
|  | Other sugars (g/day)                     | 2.30 (2.89)  | 1.63   | 0.04           | 6.32            |
|  | Alpha-carotene (µg/day)                  | 516 (644)  | 266    | 3.60           | 1651            |
|  | Beta-carotene (µg/day)                   | 2615 (2415)  | 1887   | 303            | 7024            |
|  | Beta cryptoxanthin (µg/day)              | 172 (378)  | 103    | 6.6            | 386             |
|  | Vitamin A (retinol equivalents) (µg/day) | 954 (999)  | 729    | 241            | 2243            |
|  | Biotin (µg/day)                          | 43 (16)  | 40     | 22             | 71              |
|  | Chloride (mg/day)                        | 3351 (1135)  | 3201   | 1779           | 5418            |
|  | Copper (mg/day)                          | 1.37 (0.49)  | 1.31   | 0.75           | 2.22            |
|  | Iron, haem (mg/day)                      | 0.60 (0.49)  | 0.50   | 0              | 1.44            |
|  | Iron, non-haem (mg/day)                  | 12 (3.5)   | 11     | 6.4            | 18              |
|  | Iodine (µg/day)                          | 209 (100)  | 190    | 91             | 392             |
|  | Manganese (mg/day)                       | 4.20 (1.46)  | 4.07   | 2.07           | 6.79            |
|  | Sodium (mg/day)                          | 1937 (735)   | 1831   | 946            | 3288            |
|  | Niacin equivalent (mg/day)               | 38 (11)  | 37     | 21             | 57              |
|  | Pantothenic acid (mg/day)                | 461 (884)  | 305    | 89             | 880             |
|  | Selenium (µg/day)                        | 52 (24)  | 48     | 23             | 95              |
|  | Total nitrogen (g/day)                   | 12 (4)   | 12     | 7.3            | 19              |
|  | Zinc (mg/day)                            | 9.65 (3.12)  | 9.32   | 5.24           | 15.1            |

PUFA polyunsaturated fatty acids, MUFA monounsaturated fatty acids

\*Nutrients not available in the Nutrient databank food composition tables (please see details in Supplementary methods)

Table 4Comparison of totalenergy and nutrient intakebetween previous (McCanceand Widdowson) and updated(Nutrient databank + otherupdates) in 207,144 participantsfrom UK Biobank

| Nutrient          | tt Spearman's r Percentage in the Percentage in the same same fifth adjacent fifth |      | Percentage in the same or adjacent fifth | Weighted k |
|-------------------|--|------|--|------------|
| Energy            | 0.962  | 78.7 | 98.9                                     | 0.86       |
| Protein           | 0.973  | 81.4 | 99.3                                     | 0.88       |
| Total fat         | 0.952  | 71.1 | 98.8                                     | 0.81       |
| SFA               | 0.908  | 62.3 | 96.5                                     | 0.74       |
| PUFA <sup>a</sup> | 0.887  | 58.2 | 94.6                                     | 0.71       |
| TFA               | 0.583  | 37.6 | 76.3                                     | 0.42       |
| Carbohydrates     | 0.952  | 77.1 | 98.5                                     | 0.84       |
| Total sugars      | 0.959  | 77.8 | 98.6                                     | 0.85       |
| Englyst fibre     | 0.935  | 67.8 | 97.6                                     | 0.79       |
| Alcohol           | 0.990  | 93.0 | 100.0                                    | 0.96       |
| Calcium           | 0.935  | 72.4 | 97.6                                     | 0.81       |
| Iron              | 0.939  | 67.5 | 98.2                                     | 0.79       |
| Magnesium         | 0.957  | 76.4 | 98.7                                     | 0.84       |
| Potassium         | 0.945  | 76.1 | 98.1                                     | 0.84       |
| Total carotene    | 0.894  | 61.4 | 95.2                                     | 0.73       |
| Folate            | 0.914  | 64.0 | 96.5                                     | 0.76       |
| Vitamin B6        | 0.813  | 50.7 | 89.7                                     | 0.63       |
| Vitamin B12       | 0.911  | 65.4 | 96.2                                     | 0.76       |
| Vitamin C         | 0.955  | 73.6 | 98.8                                     | 0.83       |
| Vitamin D         | 0.856  | 58.2 | 92.6                                     | 0.69       |
| Vitamin E         | 0.790  | 48.9 | 88.1                                     | 0.60       |
| Retinol           | 0.797  | 52.5 | 90.7                                     | 0.64       |

PUFA polyunsaturated fatty acids, SFA saturated fatty acids, TFA trans fatty acids

<sup>a</sup>For the Nutrient databank this is the sum of n-3 and n-6 PUFAs

the updated version. Except for TFA (r=0.58) and some of the fat-soluble vitamins, high correlations (r > 0.90) were found between nutrients calculated using the two versions: energy (r=0.96), protein (r=0.97), total fat (r=0.95), carbohydrates (r=0.95), saturated fat (r=0.91), total sugars (r=0.96), and fibre (r=0.94), with the strongest correlation being for alcohol intake (r=0.99). The percentage of agreement between the two versions was generally good, with the majority of the nutrients classified into the same or adjacent fifth ranging from 90.7% for retinol ( $\kappa = 0.64$ ) to 99.3% for protein ( $\kappa = 0.88$ ); however, the percentage agreement was lower for TFA (76.3%,  $\kappa = 0.42$ ), and slightly lower for vitamin E (88.1%,  $\kappa = 0.60$ ) and vitamin B6 (89.7%,  $\kappa = 0.63$ ). The full list of nutrients and the categorization of participants into fifths based on the previous and the updated version is shown in Tables 5 and 6, while the range of intakes within each fifth is reported in Supplementary Table 4. Finally, each food item in the updated version of the nutrient calculation was assigned to a food group, which is showed in Supplementary Table 5 and explained in detail elsewhere [25]

#### Discussion

We have described the updated version of the Oxford WebQ 24-h dietary assessment and compared it with the previous version of this questionnaire among participants in UK Biobank. In general, small absolute mean differences in nutrient intakes between the two versions were observed, and the ranking of individuals was minimally affected for most nutrients. The only substantial differences were observed for TFA and vitamin C, for which intakes in the updated version were lower and for retinol, vitamin D and E, for which intakes were higher. We have incorporated new dietary variables, which will allow researchers to assess whether they are related to non-communicable diseases. Also, with this update, we have made it easier for future users to continue this updating process using future releases of the UKNDB.

After categorising the nutrient intakes, there was very high agreement between the two versions for total energy intake and macronutrients. The closest agreement was observed for alcohol intake, for which 100% of the participants were in the same or adjacent fifth, followed by total 

 Table 5 Dietary intakes of energy, macronutrients and fibre by fifths,

 shaded cells depict participants categorised into the same (dark shading) or adjacent (light shading) quintile using the previous (McCance and Widdowson) and the updated (Nutrient databank + other updates)

|                     | 1      | Nut         | rient datab | ank           |               |
|---------------------|--------|-------------|-------------|---------------|---------------|
| McCance & Widdowson | Q1     | Q2          | Q3          | Q4            | Q5            |
| Energy              |        |             |             |               |               |
| Q                   |        | 4665        | 31          | 0             | 0             |
| Q                   |        | 30595       | 6767        | 74            | 0             |
| Q                   |        | 5368        | 28870       | 6857          | 24            |
| Q                   |        | 502         | 5198        | 30468         | 5045          |
| Q!                  | 5 177  | 299         | 563         | 4030          | 36359         |
| Protein<br>Q:       | 37372  | 3993        | 60          | 8             | 1             |
| Q.<br>Q.            |        | 31928       | 5707        | 8<br>147      | 9             |
| Q:<br>Q:            |        | 5015        | 30318       | 5738          | 9<br>87       |
| Q.                  |        | 373         | 5032        | 31775         | 4134          |
| Q!                  |        | 120         | 312         | 3761          | 37197         |
| Total fat           |        | 120         | 011         | 0,01          | 0,10,         |
| Q                   | 34662  | 6470        | 285         | 12            | 1             |
| Q                   |        | 26253       | 8291        | 542           | 12            |
| Q                   |        | 8115        | 24532       | 8139          | 288           |
| Q4                  |        | 545         | 8039        | 26702         | 6072          |
| Q                   |        | 46          | 282         | 6034          | 35055         |
| SFA                 |        |             |             |               |               |
| Q                   | 31964  | 8772        | 695         | 24            | 1             |
| Q                   | 2 7780 | 21682       | 10825       | 1145          | 23            |
| Q                   | 1181   | 8997        | 20100       | 10583         | 543           |
| Q                   | 322    | 1613        | 8728        | 22546         | 8196          |
| Q                   | 5 182  | 365         | 1081        | 7131          | 32665         |
| PUFA                |        |             |             |               |               |
| Q                   | 32247  | 7891        | 1155        | 162           | 22            |
| Q                   | 2 7920 | 20889       | 10325       | 2121          | 161           |
| Q                   | 3 1032 | 9851        | 18163       | 10885         | 1527          |
| Q4                  | 1 230  | 2640        | 9728        | 19162         | 9605          |
| Q                   | 5 0    | 158         | 2058        | 9099          | 30113         |
| Trans fat           |        |             |             |               |               |
| Q                   |        | 11056       | 5480        | 2528          | 952           |
| Q                   |        | 12235       | 11027       | 6678          | 2259          |
| Q                   |        | 8651        | 10975       | 11114         | 5433          |
| Q4                  |        | 5940        | 8458        | 12098         | 11562         |
| Q                   | 2159   | 3547        | 5489        | 9011          | 21222         |
| Carbohydrates       | 26742  | 4610        | <b>C</b> 0  |               | •             |
| Q                   |        | 4619        | 68          | 1             | 0             |
| Q                   |        | 30279       | 7083        | 190           | 2             |
| Q                   |        | 5400<br>643 | 28052       | 7553          | 101           |
| Q4<br>Q!            |        | 488         | 5414<br>812 | 29232<br>4453 | 5966<br>35359 |
| Total sugars        | 5 515  | 400         | 012         | 4455          | 22222         |
| Q:                  | 36650  | 4658        | 125         | 0             | 0             |
| Q:                  |        | 30422       | 6677        | 222           | 0             |
| Q:                  |        | 5360        | 28604       | 7003          | 84            |
| Q                   |        | 725         | 5206        | 29710         | 5600          |
| Q!                  |        | 264         | 817         | 4494          | 35744         |
| Fibre               |        | 201         | 01/         |               | 00711         |
| Q:                  | 34324  | 5742        | 1284        | 124           | 7             |
| Q                   |        | 25127       | 7195        | 1974          | 121           |
| Q                   |        | 10274       | 22479       | 7607          | 941           |
| Q4                  |        | 286         | 10342       | 24472         | 6313          |
| Q                   |        | 0           | 129         | 7252          | 34046         |
| Alcohol             |        |             |             |               |               |
| Q                   | 60178  | 10935       | 0           | 0             | 0             |
| Q                   |        | 11793       | 259         | 0             | 0             |
| Q                   | 3 0    | 139         | 40345       | 638           | 0             |
| Qé                  |        | 0           | 638         | 39902         | 1086          |
| Q                   | 5 0    | 0           | 0           | 894           | 40337         |
|                     |        |             |             |               |               |

For the Nutrient databank total PUFA was determined as the sum of n-3 and n-6 PUFAs

protein. Although the absolute intakes of carbohydrates and total sugars did not differ much between the two versions, we did observe that a small number of participants who were in the highest quintile of consumption in the previous version are now in the lowest quintile. This may be due to a concentrated fruit juice code not being sufficiently diluted with water in the previous version of the nutrient calculation. As expected, intakes of TFA were lower in the updated version of the nutrient calculation and there was moderate agreement with the previous version. Most TFA in the diet are produced when converting vegetable oils into semi-solid fats during the process of partial hydrogenation. TFA are well-established risk factors for cardiovascular disease [26], and the food industry has voluntarily reduced or eliminated some artificial TFA in processed foods in the UK in the last 15 years [27]. The previous version used FCT in which nutrient content was published from foods chemically analysed up to 2002 (including analytic data pre-dating the publication date), and, therefore, the 'true' TFA intake in 2009-2012, when the participants completed the Oxford WebQ, was likely lower [28]. This previous version also had substantial missing data for TFA, and for this reason this nutrient was not released in UK Biobank. The lower mean TFA intake in the updated version is likely an underestimated difference due to previous missing data on TFA. and also due to food reformulation over time and/or the different imputations of TFA between the two FCT versions of the nutrient calculation. The main sources of TFA in the previous version were likely to be fat spreads and desserts and biscuits, while in the updated version they are likely to be mainly naturally occurring TFA in food produced from ruminant animals. Intakes of TFA are below the dietary reference value of < 2% of total energy, and values are consistent with those reported by the UK NDNS [29].

Intakes of SFAs were also lower in the updated version of the nutrient calculation, but with high agreement in ranking between the two versions. One of the major contributors to SFA in this cohort is dairy fat spread, and, therefore, it is possible that the decrease in SFA may be due to the decrease of 20–60% in the portion sizes allocated for some spreads in the revised version (e.g. spreads on crispbreads, slices of bread, bread rolls, and oatcakes, see supplement for more details).

There were also differences in vitamin intakes between the two versions. Vitamin C intake was on average 17% lower in the updated version compared to the previous version. When vitamin C intake was divided into fifths, the majority of the participants remained classified in the same or an adjacent category. The decrease in vitamin C may be due to fruit juice, which is the largest source of vitamin C in this cohort and in which the previous version of the questionnaire had a concentrated fruit juice code not sufficiently diluted with water. On the other hand, we observed an **Table 6** Dietary intakes of micronutrients by fifths, shaded cells depict participants categorised into the same (dark shading) or adjacent (light shading) quintile using the previous (McCance and Widdowson) and the updated (Nutrient databank + other updates)

| McCance & Widdowson         Q1         Q2         Q3         Q4         Q5           Calcium         35085         5995         324         21         3           Q2         5182         27500         8217         5184         16           Q3         592         6404         25658         8555         219           Q4         522         997         6076         27321         6733           Q3         34455         6617         340         29         4           Q3         456         8723         22514         9330         450           Q3         456         8723         22514         9330         450           Q4         79         901         8786         24273         7331           Q4         136075         5120         126         8         0           Q2         44619         29561         7216         784         100           Q3         453         5370         27678         7806         122           Q4         424         737         5322         29838         6188         3           Q4         1327         7805         1884  |                | I     |       | Nutri | ent databa | ink   |       |
|--|----------------|-------|-------|-------|------------|-------|-------|
| QI<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q   |                | owson | Q1    |       |            |       | Q5    |
| Q25182275008.22155416Q359264042656862536252Q4252298760762732167337Q53175431154501734397Q42502917671732Q56673225149330450Q469723225149330450Q469018768242737331Q41096165901222745439Q410951655901222745439Q411430857845823586Q411430857845823586Q411430857845823586Q411430857845823586Q411430857845823586Q411430857845823586Q411430857845823586Q411430857845823586Q411430857812123598Q55177138212236281319Q41223628131312121303Q5114525149115023193Q51274713913821223628Q51741317130213191319Q52330114152514141520 <t< td=""><td>Calcium</td><td>01</td><td>35086</td><td>5995</td><td>324</td><td>21</td><td>3</td></t<>   | Calcium        | 01    | 35086 | 5995  | 324        | 21    | 3     |
| PronQ<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q<br>Q  |                |       |       |       |            |       |       |
| Iron0317543115450.703439703445566173409971732064312507291767173206479901876624273731308116613708033611020241235111521220461929361721522014060965185135112040195616501022274454305185512012680036175512012680036175512012680036175512012680036175512012680036175512012844273705012277805128241284180127778051282412841612778051282412841631287780512823131521359934612713817130513152135993461381772332336915213151315138171327323691521315131514813339264226368035957158934613369264226368035159 </td <td></td> <td>Q3</td> <td>592</td> <td>6404</td> <td>25658</td> <td>8556</td> <td>219</td>   |                | Q3    | 592   | 6404  | 25658      | 8556  | 219   |
| IronQi<br>Qi<br>Qi<br>A44556617<br>A202910<br>A10717<br>A2<br>A20<br>A10420<br>A10<br>A20<br>A10<br>A20<br>A10<br>A20<br>A210901<br>A200<br>A210<br>A210<br>A210<br>A210<br>A2102201<br>A210<br>A210<br>A210420<br>A210<br>A210<br>A210420<br>A210<br>A210420<br>A210<br>A210Magnesium0100<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A402<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A401<br>A4   |                |       |       |       |            |       |       |
| 01<br>02<br>03<br>04<br>04<br>02<br>04<br>04<br>04<br>04<br>04<br>053400<br>040<br>050<br>05003400<br>0400<br>0400<br>04003400<br>0400<br>0400<br>04003400<br>0400<br>0400<br>0400<br>040034000<br>04000<br>04000<br>0400034000<br>04000<br>04000<br>0400034000<br>04000<br>04000<br>0400034000<br>04000<br>04000<br>04000<br>0400034000<br>04000<br>04000<br>04000340000<br>04000<br>04000<br>040000<br>040000340000<br>040000<br>040000340000<br>040000<br>040000340000<br>040000<br>040000340000<br>040000<br>0400000340000<br>040000340000<br>040000340000<br>0400003400000<br>04000034000000000000000000000000000000000000  |                | Q5    | 317   | 543   | 1154       | 5017  | 34397 |
| Q26431<br>(3)25072<br>(373)<br>(4)9176<br>(373)<br>(4)717<br>(4)32<br>(4)Magnesium150096<br>(2)5185<br>(4)135<br>(2)112<br>(2)141<br>(4)Magnesium150096<br>(4)5185<br>(4)115<br>(2)112<br>(2)112<br>(4)122<br>(4)Magnesium160096<br>(4)5185<br>(4)112<br>(2)2200<br>(4)112<br>(4)Magnesium16616<br>(4)5001<br>(2)22975<br>(4)5439<br>(4)3586<br>(4)Potasium166175<br>(4)5120<br>(4)122<br>(4)5120<br>(4)122<br>(4)5120<br>(4)Magnesium166175<br>(4)5120<br>(4)122<br>(4)28638<br>(4)578<br>(4)122<br>(4)Potasium16177<br>(4)7373<br>(4)528<br>(4)122<br>(4)5180<br>(4)121<br>(4)Magnesium16277<br>(4)7774<br>(4)918<br>(4)618<br>(4)3361<br>(4)Total carotem16277<br>(4)7081<br>(4)131<br>(4)122<br>(4)1313<br>(4)152<br>(4)Folate133310<br>(4)7139<br>(4)818<br>(4)133<br>(4)152<br>(4)1313<br>(4)152<br>(4)Vitamin B612003<br>(4)5575<br>(4)1444<br>(4)152<br>(4)1621<br>(4)1313<br>(4)1302<br>(4)1313<br>(4)1312<br>(4)1312<br>(4)1312<br>(4)1312<br>(4)1313<br>(4)1312<br>(4)1312<br><td>Iron</td> <td>01</td> <td>24455</td> <td>6617</td> <td>240</td> <td>20</td> <td>4</td>  | Iron           | 01    | 24455 | 6617  | 240        | 20    | 4     |
| Q3<br>Q4<br>Q4456<br>P018723<br>   |                |       |       |       |            |       |       |
| PartialPart of the state of the |                |       |       |       |            |       |       |
| Magnesium         Image is a second seco       |                | Q4    | 79    | 901   | 8786       | 24273 | 7331  |
| N         1         2         4         4         3         1         2         4           Q2         4419         23361         7215         220         14           Q3         401         5959         27600         7342         127           Q4         199         616         5901         29274         5439           Q5         114         308         577         4582         35846           Q2         4189         29675         7306         229         100           Q3         453         5370         27678         7806         1128           Q4         4244         737         5322         28938         6118         3           Q2         6177         22394         12223         6628         7         3         3308           Q2         6177         22384         17215         21395         9346         336         9371         995           Folate         1         33310         7139         818         7139         3221           Q2         7253         23369         9152         1494         162           Q2         7253         23369   |                | Q5    | 8     | 116   | 613        | 7080  | 33611 |
| Q24619293617215220141Q3401956165001292745439Potasium736175573024800Q34535370276787806122Q42418829675730624901Q34535370276787806122Q42488295757306289386188Q53685279784161831Q26772223941223462878Q3182777249186131Q277249186131Q31827780518824169Q4528288173152159Q31746757213599346Q5775716281144Q452828817315Q5775716288035Q5775715288035Q5775715289157Q41631336924922636Q59861713091173817Q5203532499954Q4335551217316528Q5203532499Q43555121731652Q5203532499Q51744221168Q5203532499Q51742495Q5 <td< td=""><td>Magnesium</td><td></td><td>25005</td><td>5405</td><td>405</td><td></td><td>-</td></td<>   | Magnesium      |       | 25005 | 5405  | 405        |       | -     |
| Q3<br>Q4<br>Q4<br>Q4<br>Q4199<br>96167340127<br>7342Potasium130857022245439<br>7306Q1<br>Q2<br>Q4<br>Q4<br>Q45370276787800122<br>2499Q4<br>Q4<br>Q447375322289386188<br>2499Q4<br>Q4<br>Q447375322289386188<br>2499Q4<br>Q4<br>Q447375322289386188<br>2499Q4<br>Q42447375322289386188<br>2499Q4<br>Q422347724918613<br>3715Q2<br>Q461277905188241280<br>2499199<br>24112159Q3<br>Q2<br>Q412237724918613<br>3715PolateQ1<br>Q3<br>Q333107139818138<br>25<br>2522532139Q4<br>Q3<br>Q473339735221399324Q4<br>Q4203331359242210439371Q5<br>Q293611152779032211Vitamin B6<br>Q2<br>Q412903635512039191Q3<br>Q412955210310684713Q3<br>Q4133552439109827240Vitamin B1Q2<br>Q4203535752167010689Q4<br>Q433554700773713310Q3<br>Q41065525521670106894557Q4<br>Q4203881672295773713<br>3 <td< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td></td<>  |                |       |       |       |            |       |       |
| Q4<br>C51996.6165901292745433PotasiumQ136175512012680Q2418929675730624910Q34234737552229386138Q5368527998442735108Q5368527998442735108Q13272377749186133Q261772239412236287Q3182778051882412804169Q45174625236991521444Q5272532336991521444162Q366949324210439371995PolateQ1333109264226368035Q277252336991521444162Q366949324210439371995Q416313369264226368035Q292631165115093378Q3208811861150391093378Q430035751213165289157Q43208851020799873131Q32088171309117130233131Q430035751213165289157Q51744221154664333034Q295817442231655100 <t< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td></t<>   |                |       |       |       |            |       |       |
| PotasiumCI3610512012680Q134335370276787306122Q44435370276787306122Q42447375322289386118Q42447375322289386188Q5122236724918613Q26177223941222362877Q312277905188241280189Q26177223941222362877Q31277305188413825Q452828817135213599346Q51746252149657731903Folate13330713981813825Q272532336991521494162Q366493242104393719321Q32081136150391093378Q4300555512173165289157Q320811861150391093378Q4300555512173165289157Q4300555512173165289157Q43005555121741302917Q430055551217416633038Q430055551217316528917Q5089816722957757 <t< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td></t<>   |                |       |       |       |            |       |       |
| Q336175512012680Q24189296757306249101Q34234737552228386188Q5368527998442735108Total carotene13272377249186183Q1327237724918618199Q45272894122362871Q3182778051882412804169Q45282881731521393936Q527232336991521494162Q272532336991521494162Q36949324210439371995Q416313369264226368035Q592051512779032103Vitamin B611861150391093378Q5203532439109827240Q2986617130911738171002Q3208857512173165289157Q5203532439108827240Vitamin B1Q1335547017637311Q310657555216010689451Q310542437980954131Q310657555216710689451Q3106575552167371352Q4   |                | Q5    | 114   | 308   | 578        | 4582  | 35846 |
| QQ<br>Q4<br>Q44189<br>Q429675<br>Q47306<br>Q4249<br>Q410<br>Q4Q4453<br>Q45370<br>Q427678<br>Q47806<br>Q41223<br>Q46188<br>Q4Total caroteneQ4<br>Q422723<br>Q47724<br>Q18824<br>Q49188<br>Q4618<br>Q43<br>Q4Q4<br>Q4<br>Q4528<br>Q42881<br>Q447315<br>Q4421359<br>Q449346<br>Q44Q4<br>Q4<br>Q4528<br>Q42881<br>Q447315<br>Q4421359<br>Q449346<br>Q44Q4<br>Q4<br>Q47233<br>Q43<br>Q442043<br>Q449371<br>Q44995<br>Q44Q4<br>Q4<br>Q4163<br>Q441512<br>Q44790<br>Q4422043<br>Q449317<br>Q44Q4<br>Q4<br>Q49324<br>Q4421043<br>Q449317<br>Q449109<br>Q443378<br>Q44Q4<br>Q4<br>Q417130<br>Q441512<br>Q449109<br>Q443378<br>Q44Q4<br>Q4<br>Q42003<br>Q442610<br>Q449109<br>Q443378<br>Q44Q4<br>Q4<br>Q42035<br>Q4421043<br>Q449109<br>Q443378<br>Q44Q4<br>Q4<br>Q4<br>Q42035<br>Q442123<br>Q449109<br>Q443378<br>Q44Q4<br>Q4<br>Q4<br>Q42035<br>Q4421152<br>Q449109<br>Q443378<br>Q44Q4<br>Q4<br>Q4<br>Q42036<br>Q433721670<br>Q441867<br>Q433321670<br>Q441867<br>Q4333Vitamin CQ1<br>Q4<br>Q44<br>Q442585<br>Q447507<br>Q44313<br>Q442265<br>Q442069<br>Q44238<   | Potasium       |       |       |       |            |       |       |
| Q3<br>Q4453<br>Q45370<br>Q772427678<br>Q3<br>Q320237806<br>Q3202312223<br>Q398<br>Q4127618<br>Q3000Q4232723<br>Q4177724<br>Q3234918<br>Q1223628<br>Q4277Q326177<br>Q323422349<br>Q42312233<br>Q423628<br>Q4237Q326177<br>Q323422369<br>Q4313824<br>Q4331013824<br>Q4312830<br>Q43310FolateQ3<br>Q4<br>Q433310<br>Q4327133<br>Q43310818<br>Q4334138<br>Q43Q427253<br>Q4323369<br>Q4429152<br>Q431494<br>Q430162<br>Q4336Q4163<br>Q43001152<br>Q43007790<br>Q437832211Vitamin B6Q1<br>Q43002608<br>Q443011503<br>Q40009917<br>Q4378Q4300<br>Q4003575<br>Q437812173<br>Q430116528<br>Q4377Vitamin B12Q1<br>Q4450333049809<br>Q44509541<br>Q4450Q4450<br>Q445022660<br>Q44507577<br>Q4533130<br>Q4450Vitamin CQ1<br>Q447<br>Q5<br>Q5<br>Q525271<br>Q5091663<br>Q507133034<br>Q4Vitamin CQ2<br>Q447<br>Q5<br>Q5962596<br>Q50712597<br>Q5093171 <q< td="">Q42797<br/>Q5062597<br/>Q5077577<br/>Q517202<br/>Q509238<br/>Q5071Q4477<br/>Q59<br/>Q5002596<br/>Q50712609<br/>Q507238<br/>Q5071Q4477<br/>Q59<br/>Q5002596<br/>Q50712609<br/>Q507238<br/>Q507Q4Q50<br/>Q507<td< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td></td<></q<>   |                |       |       |       |            |       |       |
| Q4<br>Q5<br>Q6244737<br>Q53225322<br>Q8986118<br>Q5108Total carotene3272377724918613Q2<br>Q4617722394122236287Q3<br>Q4182778051882412804169Q4<br>Q452828817315213599346Q416232236991521494162Q36949324200391521494162Q416313369264226368035Q29861152779032211Vitamin B62908585102670987351Q2998617130911738171302Q32088118611503091093378Q42003357512173165289157Q42088118611503091093378Q4300357512173165289157Q310655555202664333034Q445020988167229577757Q51744221154664333034Vitamin C35989527116650Q445020988167229577757Q508842569934798Vitamin C35989527116650Q44502835075073713Q43592  |                |       |       |       |            |       |       |
| Octal caroteneOctal caroteneSignalSignalQ13222377249984427SignalQ3617722394122236287Q3182778051882412804169Q452828817315213599346Q51746252149657731903Folate0133310713981813825Q277532336991521444162Q36949324202638035371995Q416313369264226368035Q592611152779032211Vitamin B60129035851026709873511Q32088118611503091093378Q4300357512173165289157Q32088118611503091093378Q4300357512173165289157Q3208118611503091093378Q430055712173165289157Q32088118611503091093378Q4300557512173165289157Q3168520211665<0   |                |       |       |       |            |       |       |
| Total carotene         U         U         U           Q1         32723         7724         918         61         3           Q2         6177         22394         12223         628         7           Q4         528         7805         18824         12339         9346           Q4         528         2881         7315         21359         9346           Q5         174         625         2149         6577         31903           Folate         Q1         33310         7139         818         138         25           Q2         7253         23369         9152         1444         162           Q3         664         9324         21043         9371         995           Q4         163         1336         9264         22656         8035           Q3         698         1152         7070         32211           Vitamin B6         Q1         29055         1510         1652         9157           Q3         1065         755         2439         1098         27240           Q4         300         555         21670         1686         55  |                |       |       |       |            |       |       |
| Q2617722394122236287Q3182778051882412804169Q452828817315213599346Q51746252149657731903Folate0133310713981813825Q272532336991521494162Q3694932420339264226368035Q592611152779032211Vitamin B60129035851026709873511Q299035116161503091093378Q29935617130911738171302Q32088118611503091093378Q299351166150391093378Q26186243379809954131Q3100575552167010689451Q445020888167229577757Q31014422104433343334Vitamin C135989527116650Q31094155926050735920234798Vitamin D12787992223256888184Q310941652959120993418Q410498999541313351351Q3107465968982739964   | Total carotene | ~~    |       |       |            |       |       |
| Q3<br>Q4<br>Q4<br>Q52818827<br>Q52818824<br>Q53121359<br>Q13599346<br>Q53FolateQ1<br>Q333107139<br>Q4818138<br>Q5225369<br>Q5391521494<br>Q5261620<br>Q536Q1<br>Q3<br>Q4G644<br>Q52492035<br>Q53691521494<br>Q5261620<br>Q5379955<br>Q5379955Vitamin B6Q1<br>Q9862603<br>Q52719117<br>Q5373817<br>Q52711302<br>Q537Vitamin B12Q1<br>Q3355420171<br>Q52072629<br>Q53716528<br>Q52079157<br>Q537Vitamin B12Q1<br>Q3355420171<br>Q5207629<br>Q53716652<br>Q52079157<br>Q5377Vitamin B12Q1<br>Q357535107<br>Q5207269<br>Q5371663<br>Q537552020<br>Q53Vitamin CQ1<br>Q355535207<br>Q537110689<br>Q545451<br>Q52073777<br>Q5Vitamin CQ1<br>Q359825271<br>Q519610689<br>Q540451<br>Q52073771<br>Q53Vitamin CQ1<br>Q359825271<br>Q519616663<br>Q55933094Vitamin DQ1<br>Q2<br>Q519628350<br>Q51977777<br>Q51733<br>Q5<br>Q5196Vitamin DQ1<br>Q2<br>Q4Q2<br>Q425297<br>Q47777<br>Q423263<br>Q4799Vitamin DQ1<br>Q2<br>Q4Q3<br>Q4Q3<br>Q4472597<br>Q49982749<br>Q42Q4<br>Q4Q47<br>Q422596<br>Q437Q48<br>Q4982749<br>Q42Q4<br>Q40Q47<br>Q42Q59<br>Q447Q498<br>Q498Q498<br>   |                |       |       |       | 918        | 61    | 3     |
| PolateQ4<br>Q52528<br>17427315<br>Q5221389<br>Q549346<br>Q57731903Folate01<br>Q<br>Q5725323369<br>Q549152<br>Q5231494<br>Q5264162<br>Q52658035<br>Q52649152<br>Q52651494<br>Q5265162<br>Q5265Q4<br>Q5<br>Q51664<br>Q52659152<br>Q52651494<br>Q5266162<br>Q52659057<br>Q52769877<br>Q52769877<br>Q5276Vitamin B611<br>Q520352610<br>Q52079877<br>Q527603511<br>Q52769877<br>Q527603511<br>Q5276Vitamin B1211<br>Q5207200757<br>Q52777716528<br>Q52769157<br>Q5277777<br>Q5291866<br>Q5287557<br>Q5277777Vitamin B1211<br>Q5377833036<br>Q5277777716673<br>Q52777777777777777777777777777777777777   |                |       |       |       |            |       |       |
| Folate051746252149657731903Q133310713981813825Q272532336991521494162Q36449324210439371995Q416313369264226368035Q592611152779032211Vitamin B612903585102670987551Q2998617130911738171302Q32088118611503091093378Q4300357512173165289157Q32088118611503091093378Q4300357512173165289157Q4300357512173165289157Q26186243379809954131Q3106575052167010689451Q3106527552167010689451Q445020988167229577757Q313797060260167955202Q44776596898273996425Q51044118571959126093378Q445227159490222766371Q445227159490222766371Q4104118571959126092386Q514015071959   |                |       |       |       |            |       |       |
| Folate         Q1         33310         7139         818         138         25           Q2         7253         2369         9152         1494         162           Q3         664         9324         21043         9371         995           Q4         163         1336         9264         22636         8035           Q5         9         261         1152         7790         32211           Vitamin B6         1         29035         8510         2670         987         351           Q1         29035         8510         2670         987         351           Q2         9866         17130         9117         3817         1302           Q3         2088         11861         15030         9109         3378           Q4         300         3575         12173         16528         9157           Q3         1065         7555         21670         10689         451           Q3         1065         7555         21670         10689         451           Q3         1074         422         10461         22957         7757           Q5         174         <   |                |       |       |       |            |       |       |
| Q133310713981813825Q272532336991521494162Q36449324210439371995Q416313369264226368035Q2985102670987351Q2998617130911738171302Q3208817180911738171302Q3208817181120293789157Q4300557512173165289157Q52035324391098827240Vitamin B1276293133166755521670Q3106575552167010689451Q445020988167229577757Q310744221154664333034Vitamin C135989527116650Q2519628350750737133Q31977060260167955202Q44706596898273996425Q410411857195912609238Q31977060260167955202Q4473659689827396425Q508274992056371Q4104118571959126093378Q46522715949922276   | Folate         | α.,   | 1/4   | 025   | 2145       | 0377  | 51505 |
| Q366949324210439371995Q416313369264226368035Q592013277032211Vitamin B612903585102670987351Q2998617130911738171302Q32088118611503091093378Q4300357512173165289157Q52035324391088827240Vitamin B12133554701762918655Q26186243379809954131Q310557557202355310689451Q445020988167229577757Q51744221154664333034Vitamin C121154664333034Q251962835075073713Q313797060260167955202Q44776596898273996425Q42108181369516897Vitamin D12787992223256888184Q21044118571959126092336Q465227159490222766371Q42041607100554240908Q5140418571959126092336Q514041607 <td></td> <td>Q1</td> <td>33310</td> <td>7139</td> <td>818</td> <td>138</td> <td>25</td>  |                | Q1    | 33310 | 7139  | 818        | 138   | 25    |
| Q4<br>Q5<br>Q5         163<br>Q5<br>Q9         1132<br>Q6<br>Q6<br>Q9986         11152<br>Q6<br>Q9986         2670<br>Q987         351<br>Q6<br>Q9986           Q1<br>Q3<br>Q0         29035         8510         2670         987         351<br>Q6<br>Q9986           Q2         9986         17130         9117         3817         1302<br>Q3<br>Q3         3019         3378           Q4<br>Q3         2088         11861         15030         9109         3378           Q4<br>Q3         200         3575         12173         16528         9157           Q4<br>Q3         200         3575         12173         16528         9157           Q4<br>Q3         1065         24337         9809         954         131           Q3         1065         24337         9809         954         131           Q3         1065         24337         9809         954         131           Q3         1057         22957         7757         33         303           Q4         450         22957         7757         33         303           Vitamin C         1         35988         5271         1666         5         0           Q3         197         7060         26016         7955  |                | Q2    | 7253  | 23369 | 9152       | 1494  | 162   |
| Nitamin B6         9         261         1152         7790         32211           Vitamin B6         01         29035         8510         2670         987         3132           Q2         9986         17130         9117         3817         1302           Q3         2088         11861         15030         9109         3378           Q4         300         3575         12173         16528         9157           Q5         20         333         2439         1085         27240           Vitamin B12         133554         7017         629         186         55           Q2         6186         24337         9809         954         131           Q3         1065         7555         21670         10689         451           Q4         450         2098         8177         1663         33034           Vitamin C         1         35989         5271         166         5         0           Q2         5196         28500         7559         2020         2356         34799           Vitamin C         1         27879         9222         3256         888         184 </td <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>  |                |       |       |       |            |       |       |
| Vitamin B6         Vitamin B6           Q1         29035         8510         2670         987         351           Q2         9986         17130         9117         3817         1302           Q3         2088         11861         15030         9109         3378           Q4         300         5575         12173         16528         9157           Q5         20         353         2439         10988         27240           Vitamin B12  |                |       |       |       |            |       |       |
| Q12903585102670987351Q2998617130911738171302Q3208811861150391093378Q4300357512173165289157Q52035324391098827240Vitamin B121335547017629186555Q261682437920510689451Q3106575552167010689451Q3106575552167010689451Q445020988167229577757Q51744221154664333034Vitamin C135989527116650Q2519628350750737133Q31977060260167955202Q44776596898273996425Q50881844595934798Vitamin D12787992223256888184Q2104411857195912609238Q3231810541181369516897Q465227159490222766371Q4104010677105854240908Q5104411857195912609238Q410310673162792683738Q510407 <td< td=""><td>Vitamin P6</td><td>QS</td><td>9</td><td>261</td><td>1152</td><td>7790</td><td>32211</td></td<>   | Vitamin P6     | QS    | 9     | 261   | 1152       | 7790  | 32211 |
| Q2         9986         17130         9117         3817         1302           Q3         2088         11861         15030         9109         3378           Q4         300         3575         12173         16528         9157           Q2         20         353         2439         10988         27240           Vitamin B12         1         33554         7017         629         186         55           Q2         6186         24337         9809         954         131           Q3         1065         2755         2105         10689         451           Q3         1050         2755         2105         2757         7757           Q5         174         422         1154         6643         33034           Vitamin C         1         35989         2571         166         5         0           Q3         137         7060         26016         7955         202           Q4         477         659         6898         27399         6425           Q1         27879         9222         3256         888         184           Q2         10441  | Vitamin Bo     | 01    | 29035 | 8510  | 2670       | 987   | 351   |
| Q4         300         3575         12173         16528         9157           Q5         20         353         2439         10988         27240           Vitamin B12         1         33554         7017         629         186         55           Q2         6186         24337         9809         954         131           Q3         1065         7555         21670         10689         451           Q3         1076         2098         8167         22957         7757           Q5         174         420         104         30334           Vitamin C         1         35989         5271         166         5         0           Q2         5196         28350         7507         371         3           Q3         197         7060         26016         7955         202           Q4         477         659         6898         27399         6425           Q3         0         89         951         2609         3378           Vitamin D         1         27879         9222         3256         888         184           Q2         10441         18571 </td <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>  |                |       |       |       |            |       |       |
| Q5         20         353         2439         10988         27240           Vitamin B12         1         33554         7017         629         186         55           Q2         66166         24337         9809         954         131           Q3         1065         7555         21670         10689         451           Q4         450         2098         8167         22957         7757           Q5         174         422         1154         6643         33034           Vitamin C         1         35989         5271         166         5         0           Q2         5196         28350         7507         371         3           Q3         197         7060         26016         7955         202           Q4         447         659         6898         27399         6425           Q3         197         7060         26016         7955         202           Vitamin D         1         27879         9222         3256         888         184           Q2         10441         18571         9591         2609         238           Q3         23   |                | Q3    | 2088  | 11861 | 15030      | 9109  | 3378  |
| Vitamin B12         Vitamin B12           Q1         33554         7017         629         186         55           Q2         6186         2437         9809         954         131           Q3         1065         7555         21670         10689         451           Q3         1065         7555         21670         10689         451           Q4         450         2098         8167         22557         7757           Q5         174         422         1154         6643         33034           Vitamin C         1         35989         5271         166         5         0           Q3         197         7060         26016         7955         202           Q4         47         659         6898         27399         6425           Q5         0         89         842         5699         34798           Vitamin D         1         27879         9222         3256         888         184           Q2         10441         18571         9591         2609         2386           Q3         2318         10541         18136         9516         897  |                |       |       |       |            |       |       |
| Q1         33554         7017         629         1.86         55           Q2         6186         24337         9809         954         1.31           Q3         1065         2755         21670         10689         451           Q4         450         2098         8167         22957         7757           Q5         174         422         1154         6643         33034           Vitamin C         1         35988         5271         166         5         0           Q2         5196         28300         7507         371         3           Q3         197         7600         26016         7955         202           Q4         477         659         6898         27399         6425           Q3         197         7606         26016         7955         202           Q4         477         659         888         184           Q2         10441         1851         9516         897           Q3         140         18136         9516         897           Q4         652         2715         9490         22276         6371   |                | Q5    | 20    | 353   | 2439       | 10988 | 27240 |
| Q2         6686         24337         9809         954         131           Q3         1065         7555         21670         10689         451           Q4         450         2098         8167         22957         7757           Q4         450         2098         8167         22957         7757           Q4         450         2098         8167         22957         7757           Q4         174         2098         5271         166         5         0           Q2         5196         28350         7507         371         3           Q3         197         7060         26016         7955         202           Q4         47         669         6898         27399         6425           Q5         0         89         842         5591         209         238           Q3         1041         18571         9591         209         238           Q3         20141         18571         9591         209         238           Q3         218         10404         379         956         6410         3378           Q4         1044         379  | Vitamin B12    | 01    | 33554 | 7017  | 629        | 186   | 55    |
| Q3         1065         7555         21670         10689         451           Q4         450         2098         8167         22957         7757           Q5         174         422         114         6643         33034           Vitamin C         135988         5271         166         5         0           Q2         5196         28350         7507         371         3           Q3         197         7060         26016         7955         202           Q4         477         659         6898         27399         6425           Q4         477         659         6898         27399         6425           Q4         477         659         3285         3479         5227           Vitamin D         1         27879         9222         3256         888         184           Q2         10441         18571         9591         2609         2338           Q3         2318         0511         18136         9516         6371           Q5         140         373         955         6140         33738           Vitamin E         1         27402 <t< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td></t<>   |                |       |       |       |            |       |       |
| Q5         174         422         1154         6643         33034           Vitamin C         1         35989         5271         166         5         0           Q2         5196         28350         7507         371         3           Q3         197         7060         26016         7955         202           Q4         477         659         6898         27399         6425           Q5         0         89         842         5699         34798           Vitamin D         1         27879         9222         3256         888         184           Q2         10441         18571         9591         2609         2338           Q3         2318         10541         18136         9516         897           Q4         652         2715         9490         22276         6371           Q4         652         2715         9490         22276         6371           Q4         652         2715         9490         22276         6371           Q4         10307         10095         4424         908           Q2         10047         16007         1009   |                |       |       |       |            |       |       |
| Vitamin C         Vitamin C           Q1         35988         5271         166         5         0           Q2         5196         28500         7507         371         3           Q3         197         7060         26016         7955         202           Q4         477         659         6898         27399         6425           Q5         0         89         842         5699         34798           Vitamin D         1         27879         9222         3256         888         184           Q2         10441         18571         9591         2609         238           Q3         2318         10541         18136         9516         897           Q4         652         2715         9490         22276         6371           Q3         140         1807         10095         4240         908           Q4         652         2715         9490         22276         6371           Q4         1602         10037         10095         4240         908           Q2         10047         16007         10095         4240         908  |                | Q4    | 450   | 2098  | 8167       | 22957 | 7757  |
| Q1         35989         5271         166         5         0           Q2         5196         28350         7507         371         3           Q3         197         7060         26016         7955         202           Q4         47         669         6898         27399         6425           Q4         47         659         6898         27399         6425           Q5         0         89         5261         7989         34798           Vitamin D         1         27879         9222         3256         888         184           Q2         10441         18571         9591         2609         238           Q3         2318         10451         1816         9516         6371           Q4         652         2715         9490         22276         6371           Q5         140         379         956         6140         33738           Vitamin E         1         27402         9703         3263         967         206           Q3         2826         10878         14262         10367         3193           Q4         717         3393   |                | Q5    | 174   | 422   | 1154       | 6643  | 33034 |
| Q2         5196         28350         77507         371         3           Q3         197         7060         26016         7955         202           Q4         47         659         6898         27399         6425           Q4         47         659         6898         27399         6425           Q4         47         659         8898         27399         6425           Q4         0         9         9222         3256         888         184           Q2         10441         18571         9591         2609         238           Q3         2318         10541         18136         9516         897           Q4         652         2715         9490         22276         6371           Q5         140         3793         955         6160         33738           Vitamin E         1         27402         9723         3263         967         206           Q3         10047         16007         10095         4420         908         3133           Q3         2826         16878         14262         10367         3193           Q4         717  | Vitamin C      |       | 25000 | 5074  | 466        | -     |       |
| Q3         197         7060         26016         7955         202           Q4         47         659         6898         27399         6425           Q5         0         89         842         5699         34798           Vitamin D         1         27879         9222         3256         888         184           Q2         10441         18571         9591         2609         238           Q3         2318         10541         18136         9516         897           Q4         652         2715         9490         22276         6371           Q4         652         2715         9490         22276         6371           Q4         652         2715         9490         22276         6371           Q4         6452         2715         9490         22276         6371           Q5         140         3738         3263         967         206           Q2         10047         16007         10955         4240         908           Q3         2826         10873         16227         9628         27493           Q4         717         3930         1   |                |       |       |       |            |       |       |
| Q4         47         659         6898         27399         6425           Q5         0         89         842         5699         34798           Vitamin D         1         27879         9222         3256         888         184           Q2         10441         18571         9591         2609         238           Q3         2318         10541         18136         9516         897           Q4         652         2715         9490         22276         6371           Q5         140         9733         3263         967         206           Q2         10047         16007         10095         4240         908           Q3         2826         16878         16227         9628         27493           Q4         717         3930         10837         16227         9628         27493           Q4         107 <td< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td></td<>  |                |       |       |       |            |       |       |
| Q5         0         89         842         5699         34798           Vitamin D         1         27879         9222         3256         88         184           Q2         10441         1857         9591         2609         238           Q3         2318         10541         18136         9516         6897           Q4         652         2715         9490         22276         6371           Vitamin E         1         27402         9793         3263         967         2060           Q2         10047         16007         10095         4240         908         3233           Vitamin E         1         27402         9723         3263         1627         3193           Q2         10047         16007         10095         4240         908         3133         3193           Q3         3285         10878         14262         10367         3193           Q4         717         3930         10837         16227         9628         27493           Retinol         1         28876         7488         2386         857         13122           Q2         10585   |                |       |       |       |            |       |       |
| Q1         22879         9222         3256         888         184           Q2         10441         18571         9591         2609         238           Q3         2318         10541         18136         9516         897           Q4         652         2715         9490         22276         6371           Q5         140         373         956         6140         33738           Vitamin E         1         27402         9723         3263         967         2066           Q3         2826         10807         10095         4240         908           Q3         2826         10878         14262         9628         3193           Q4         717         3930         10837         16227         9628           Q5         437         891         2972         9628         27493           Q5         10585         18290   |                |       | 0     | 89    |            |       | 34798 |
| Q2         10441         18571         9591         2609         238           Q3         2318         10541         18136         9956         897           Q4         652         2715         9490         22276         6371           Q4         652         2715         9490         22276         6371           Vitamin E         11         27402         9723         3263         967         2066           Q2         10047         16007         10095         4240         908           Q3         2826         10367         10295         4240         908           Q4         717         3303         10837         16227         9628           Q5         437         891         2972         9628         27493           Retinol         1         28876         781         2927         9628         27493           Q1         10585         18290         7516         2607         1912           Q2         10585         18290         7516         2607         1912           Q3         1753         12638         16394         7145         2994           Q4         202  | Vitamin D      |       |       |       |            |       |       |
| Q3         2318         10541         18136         9516         897           Q4         652         2715         9490         22276         6371           Q5         140         379         956         6140         33738           Vitamin E         1         27402         9723         3263         967         206           Q2         10047         16007         10095         4240         908           Q3         2826         10878         14262         10367         3193           Q4         717         3930         10837         16227         9628           Q5         437         891         2972         9628         27493           Retinol         1         28876         7468         2366         857         13122           Q2         10585         18290         7516         2607         1912           Q3         1753         12618         16394         7145         2994           Q4         202         2868         13135         17935         6767   |                |       |       |       |            |       |       |
| Q4         652         2715         9490         22276         6371           Q5         140         379         956         6140         33738           Vitamin E         1         27402         9723         3263         967         206           Q1         27402         9723         3263         967         206           Q2         10047         16007         10095         4240         908           Q3         2826         10878         14262         10367         3193           Q4         717         3930         10837         16227         9628           Q5         437         891         2972         9628         27493           Retinol         1         28876         7468         2386         857         1322           Q2         10585         18290         7516         2607         1912           Q3         1753         12618         16394         7145         2994           Q4         202         2868         13135         17935         6767  |                |       |       |       |            |       |       |
| Q5         140         379         956         6140         33738           Vitamin E         Q1         27402         9723         3263         97         206           Q2         10047         16007         10095         4240         908           Q3         2826         10878         14262         10377         3193           Q4         717         3930         10837         16227         9628           Q5         437         891         2972         9628         27493           Retinol          2         10585         1322         9628         27493           Q1         28876         77468         2386         857         1322           Q2         10585         18290         7516         2607         1912           Q3         1753         12618         16394         7145         2994           Q4         202         2868         13135         17935         6767  |                |       |       |       |            |       |       |
| Vitamin E         Q1         27402         9723         3263         967         206           Q2         10047         16007         10095         4240         908           Q3         2826         10878         14262         10367         3193           Q4         717         3930         16327         9628         27493           C5         437         891         2972         9628         27493           Retinol         1         28876         7468         2386         857         1322           Q2         10585         18290         7516         2607         1912         233         1753         12618         16394         7145         2994           Q4         202         2868         13135         17935         66767  |                |       |       |       |            |       |       |
| Q2         10047         16007         10095         4240         908           Q3         2826         10878         14262         10367         3193           Q4         717         3930         10837         16227         9628           Q5         437         891         2972         9628         27493           Retinol         1         28876         7468         2386         857         1322           Q2         10585         18290         7516         2607         1912           Q3         1753         12618         16394         7145         2994           Q4         202         2868         13135         17935         6767   | Vitamin E      |       |       |       |            |       |       |
| Q3         2826         10878         14262         10367         3193           Q4         717         3930         10837         16227         9628           Q5         437         891         2972         9628         27493           Q1         28876         7468         2386         857         1322           Q2         10585         18290         7516         2607         1912           Q3         1753         12618         16394         7145         2994           Q4         202         2868         13135         17935         6767  |                |       |       |       |            |       |       |
| Q4         717         3930         10837         16227         9628           Q5         437         891         2972         9628         27493           Retinol         1         28876         7468         2386         857         1322           Q1         28876         14829         7516         2607         1912           Q3         1753         12618         16394         7145         2994           Q4         202         2868         13135         17935         6767  |                |       |       |       |            |       |       |
| Q5         437         891         2972         9628         27493           Retinol         1         28876         7468         2386         857         1322           Q1         28876         18290         7516         2607         1912           Q3         1753         12618         16394         7145         2994           Q4         202         2868         13135         17935         66767  |                |       |       |       |            |       |       |
| Retinol         28876         7468         2386         857         1322           Q2         10585         18290         7516         2607         1912           Q3         1753         12618         16394         7145         2994           Q4         202         2868         13135         17935         6767  |                |       |       |       |            |       |       |
| Q21058518290751626071912Q31753126181639471452994Q4202286813135179356767  | Retinol        | ~     |       |       |            |       |       |
| Q3         1753         12618         16394         7145         2994           Q4         202         2868         13135         17935         6767   |                |       |       |       | 2386       | 857   | 1322  |
| Q4 202 2868 13135 17935 6767   |                |       |       |       |            |       |       |
|  |                |       |       |       |            |       |       |
| 23 13 103 1350 12003 23820   |                |       |       |       |            |       |       |
|  |                | 44    | 13    | 105   | 1330       | 12000 | 23020 |

increase in the intake estimates of retinol and vitamins D and E, although there was substantial agreement between the two versions when these nutrients were categorised. This may be due to the incorporation of fats used when cooking in this updated version, which were mainly vegetable oils; increases in vitamin D may also have occurred due to increases in food fortification, although no fortified foods were preferred when allocating food codes to the WebQ items. Moreover, differences in micronutrient content between the different FCTs are to be expected even if these FCT were created from similar sources; this may be due to for example food reformulation, re-analysis of foods resulting in differences due to storage conditions, fortification or season when the food was sampled. Lastly, imputation of missing values in the UKNDB may have contributed to changes in the nutrient intakes observed [30].

Among the new dietary variables that have been incorporated in this updated version, are MUFAs, n-3 and n-6 PUFAs. The UKNDB does not have information on total essential PUFAs, but n-3 and n-6 fatty acids account for the vast majority of PUFAs in the diet; therefore, researchers using this resource could sum these two fatty acids as a proxy of total PUFA. Other dietary variables that have been incorporated are animal and plant fat and protein, and free sugars. The mean intake of free sugars in this population is slightly above the recommended value of < 10% of total energy intake by the World Health Organization [31].

This study has some strengths and limitations. The updated FCT has over three times more food codes than the previous one, which allowed for a better matching between reported food intakes and nutrient composition. This updated version of the nutrient calculation was developed to improve accuracy and in very few cases also validity (where the original food code did not accurately match the food description in the WebQ) of the dietary intakes of the participants when they completed the questionnaire, and so it is expected to decrease measurement error. Nondifferential misclassification of dietary intakes may attenuate the relationship in diet-disease associations in prospective studies [32]. However, it should be emphasized that, as in all questionnaire-based assessments of dietary intake, there will be some measurement error, especially systematic bias due to underreporting [20].

In conclusion, we have described an updated version of the nutrient calculation of the Oxford WebQ 24-h dietary assessment and compared it with the previous version. Small absolute group differences in nutrient intakes between the two versions were observed and the ranking of individuals was minimally affected for most nutrients. The greatest differences were observed for TFA and vitamin C, for which intakes in the updated version were lower; and for retinol, vitamin D and E, for which the reported intakes were higher. This updated version of the nutrient calculation was developed to improve accuracy and personalisation of the dietary intakes of the participants and, therefore, some reduction in non-differential misclassification in diet–disease associations is expected. This new version of the nutrient calculation and new dietary variables will be returned to UK Biobank, together with a food grouping system developed using this updated version of the nutrient calculation [25].

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00394-021-02558-4.

Acknowledgements The food composition data used in this paper were taken from the National Diet and Nutrition Survey (NDNS) and accessed with kind permission of the UK Data Service. We wish to express our gratitude to the participants and those involved in building the UK Biobank resource. This work has been conducted using the UK Biobank Resource under Application Number 24494. We would also like to thank researchers involved in the previous versions of the Oxford WebQ questionnaire.

**Funding** This research received no specific grant from any funding agency, commercial or not-for-profit sectors. APC is supported by a Cancer Research UK Population Research Fellowship (C60192/A28516) and by the World Cancer Research Fund (WCRF UK), as part of the Word Cancer Research Fund International grant programme (2019/1953).

Availability of data and material UK Biobank is an open access resource. Bona fide researchers can apply to use the UK Biobank data set by registering and applying at http://www.ukbiobank.ac.uk/regis ter-apply.

#### Declarations

**Conflict of interest** The authors declare that there are no conflicts of interest.

**Ethics approval** The UK Biobank study was conducted according to the guidelines laid down in the Declaration of Helsinki and approved by the North West Multi-Centre Research Ethics Committee (reference number 06/MRE08/65).

**Consent to participate** All participants gave informed consent to participate and be followed up through data linkage at recruitment.

**Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

#### References

- Hooson Jzh J, Hutchinson Jyh J, Warthon-Medina M, Hancock N, Greathead K, Knowles B, Vargas-Garcia E, Gibson LE, Bush LA, Margetts B, Robinson S, Ness A, Alwan NA, Wark PA, Roe M, Finglas P, Steer T, Page P, Johnson L, Roberts K, Amoutzopoulos B, Burley VJ, Greenwood DC, Cade JE (2019) A systematic review of reviews identifying UK validated dietary assessment tools for inclusion on an interactive guided website for researchers: www.nutritools.org. Crit Rev Food Sci Nutr. https://doi.org/ 10.1080/10408398.2019.1566207
- Liu B, Young H, Crowe FL, Benson VS, Spencer EA, Key TJ, Appleby PN, Beral V (2011) Development and evaluation of the Oxford WebQ, a low-cost, web-based method for assessment of previous 24 h dietary intakes in large-scale prospective studies. Public Health Nutr 14(11):1998–2005. https://doi.org/10.1017/ S1368980011000942
- Fry A, Littlejohns TJ, Sudlow C, Doherty N, Adamska L, Sprosen T, Collins R, Allen NE (2017) Comparison of sociodemographic and health-related characteristics of UK Biobank participants with those of the general population. Am J Epidemiol 186(9):1026– 1034. https://doi.org/10.1093/aje/kwx246
- Green J, Reeves GK, Floud S, Barnes I, Cairns BJ, Gathani T, Pirie K, Sweetland S, Yang TO, Beral V, Million Women Study C (2019) Cohort profile: the million women study. Int J Epidemiol 48(1):28–29e. https://doi.org/10.1093/ije/dyy065
- Holland B, Unwin ID, Buss DH (1988) Cereals and cereal products. Third supplement to McCance and Widdowson's The composition of foods, 4th edn. Royal Society of Chemistry, Cambridge
- Holland B, Unwin ID, Buss D (1989) Milk products and eggs. Fourth supplement to McCance and Widdowson's The composition of foods, 4th edn. Royal Society of Chemistry, Cambridge
- Holland B, Welch AA, Unwin ID, Buss DH, Paul AA, Southgate D (1991) McCance and Widdowson's The composition of foods, 5th edn. Royal Society of Chemistry, Cambridge
- Holland B, Unwin ID, Buss DH (1991) Vegetables, herbs and spices. Fifth supplement to McCance and Widdowson's The composition of foods, 4th edn. Royal Society of Chemistry, Cambridge
- 9. Holland B, Unwin ID, Buss DH (1992) Fruit and nuts. First supplement to McCance and Widdowson's The composition of foods, 5th edn. Royal Society of Chemistry, Cambridge
- Holland B, Welch AA, Buss DH (1992) Vegetable dishes. Second supplement to McCance and Widdowson's The composition of foods, 5th edn. Royal Society of Chemistry, Cambridge
- Holland B, Brown J, Buss DH (1993) Fish and fish products. Third supplement to McCance and Widdowson's The composition of foods, 5th edn. Royal Society of Chemistry, Cambridge
- Chan W, Brown J, Buss DH (1994) Miscellaneous foods. Fourth supplement to McCance and Widdowson's The composition of foods, 5th edn. Royal Society of Chemistry, Cambridge
- Chan W, Brown J, Lee SM, Buss DH (1995) Meat, poultry and game. Fifth supplement to McCance and Widdowson's The composition of foods, 5th edn. Royal Society of Chemistry, Cambridge
- Chan W, Brown J, Church SM, Buss DH (1996) Meat products and dishes. Sixth supplement to McCance and Widdowson's The composition of foods, 5th edn. Royal Society of Chemistry, Cambridge
- 15. Agency FS (2002) McCance and Widdowson's The composition of foods, sixth, summary. Royal Society of Chemistry, Cambridge
- Swan G, Dodhia S, Farron-Wilson M, Powell N, Bush M (2015) Food composition data and public health. Nutr Bull 40(3):223– 226. https://doi.org/10.1111/nbu.12156
- 17. NatCen Social Research, MRC Elsie Widdowson Laboratory, University College London. Medical School (2015) National Diet and

Nutrition Survey Years 1-6, 2008/09-2013/14. [data collection]. 7th Edition. UK Data Service. SN: 6533, https://doi.org/10.5255/ UKDA-SN-6533-7

- Sudlow C, Gallacher J, Allen N, Beral V, Burton P, Danesh J, Downey P, Elliott P, Green J, Landray M, Liu B, Matthews P, Ong G, Pell J, Silman A, Young A, Sprosen T, Peakman T, Collins R (2015) UK biobank: an open access resource for identifying the causes of a wide range of complex diseases of middle and old age. PLoS Med 12(3):e1001779. https://doi.org/10.1371/journal.pmed. 1001779
- Ministry of Agriculture FaF (1993) Food portion sizes, 2nd edn. HMSO, London
- Greenwood DC, Hardie LJ, Frost GS, Alwan NA, Bradbury KE, Carter M, Elliott P, Evans CEL, Ford HE, Hancock N, Key TJ, Liu B, Morris MA, Mulla UZ, Petropoulou K, Potter GDM, Riboli E, Young H, Wark PA, Cade JE (2019) Validation of the Oxford WebQ online 24-hour dietary questionnaire using biomarkers. Am J Epidemiol 188(10):1858–1867. https://doi.org/10.1093/ aje/kwz165
- Johnson L, Mander AP, Jones LR, Emmett PM, Jebb SA (2008) A prospective analysis of dietary energy density at age 5 and 7 years and fatness at 9 years among UK children. Int J Obes (Lond) 32(4):586–593. https://doi.org/10.1038/sj.ijo.0803746
- 22. Scientific Advisory Committee on Nutrition. Carbohydrates and Health (2015). https://www.gov.uk/government/uploads/system/ uploads/attachment\_data/file/445503/SACN\_Carbohydrates\_and\_ Health.pdf. Accessed June 2020
- 23. Willett W (2012) Nutritional epidemiology, 3rd edn. Oxford University Press, Oxford
- 24. McHugh ML (2012) Interrater reliability: the kappa statistic. Biochem Med (Zagreb) 22(3):276–282
- 25. Piernas C, Perez-Cornago A, Gao M, Young H, Pollard Z, Mulligan A, Lentjes M, Carter J, Bradbury KE, Key TJ, Jebb SA

(2021) Describing a new food group classification system for UK Biobank: analysis of food groups and sources of macro- and micronutrients in 208,200 participants. Eur J Nutr. https://doi.org/10.1007/s00394-021-02535-x

- Mozaffarian D, Katan MB, Ascherio A, Stampfer MJ, Willett WC (2006) Trans fatty acids and cardiovascular disease. N Engl J Med 354(15):1601–1613. https://doi.org/10.1056/NEJMra054035
- Coombes R (2011) Trans fats: chasing a global ban. BMJ 343:d5567. https://doi.org/10.1136/bmj.d5567
- National Diet and Nutrition Survey Years 1 to 9 of the Rolling Programme (2008/2009—2016/2017): time trend and income analyses. Public Health England
- 29. Pot GK, Prynne CJ, Roberts C, Olson A, Nicholson SK, Whitton C, Teucher B, Bates B, Henderson H, Pigott S, Swan G, Stephen AM (2012) National Diet and Nutrition Survey: fat and fatty acid intake from the first year of the rolling programme and comparison with previous surveys. Br J Nutr 107(3):405–415. https://doi.org/10.1017/S0007114511002911
- Public Health England and Food Standards Agency. National Diet and Nutrition Survey Years 5–6 2012/13–2013/14 User Guide for UK Data. http://doc.ukdataservice.ac.uk/doc/6533/mrdoc/pdf/ 6533\_ndns\_yrs5-6\_uk\_user\_guide.pdf. Accessed 07 Aug 2020
- 31. World Health Organization (2015) Information note about intake of sugars recommended in the WHO guideline for adults and children. https://www.who.int/nutrition/publications/guidelines/ sugar\_intake\_information\_note\_en.pdf?ua=1#:~:text=The% 20World%20Health%20Organization's%20new,10%25%20of% 20total%20energy%20intake. Accessed Nov 2020
- 32. Subar AF, Freedman LS, Tooze JA, Kirkpatrick SI, Boushey C, Neuhouser ML, Thompson FE, Potischman N, Guenther PM, Tarasuk V, Reedy J, Krebs-Smith SM (2015) Addressing current criticism regarding the value of self-report dietary data. J Nutr 145(12):2639–2645. https://doi.org/10.3945/jn.115.219634