

## The acceptability of repeat Internet-based hybrid diet assessment of previous 24-h dietary intake: administration of the Oxford WebQ in UK Biobank

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### Abstract

Although dietary intake over a single 24-h period may be atypical of an individual's habitual pattern, multiple 24-h dietary assessments can be representative of habitual intake and help in assessing seasonal variation. Web-based questionnaires are convenient for the participant and result in automatic data capture for study investigators. This study reports on the acceptability of repeated web-based administration of the Oxford WebQ – a 24-h recall of frequency from a set food list suitable for self-completion from which energy and nutrient values can be automatically generated. As part of the UK Biobank study, four invitations to complete the Oxford WebQ were sent by email over a 16-month period. Overall, 176 012 (53 % of those invited) participants completed the online version of the Oxford WebQ at least once and 66 % completed it more than once, although only 16 % completed it on all four occasions. The response rate for any one round of invitations varied between 34 and 26 %. On most occasions, the Oxford WebQ was completed on the same day that they received the invitation, although this was less likely if sent on a weekend. Participants who completed the Oxford WebQ tended to be white, female, slightly older, less deprived and more educated, which is typical of health-conscious volunteer-based studies. These findings provide preliminary evidence to suggest that repeated 24-h dietary assessment via the Internet is acceptable to the public and a feasible strategy for large population-based studies.

**Key words:** Diet: Internet: Dietary assessment: Acceptability

The role of diet in a healthy lifestyle is widely acknowledged, but the contribution of specific nutrients and their impact on chronic disease remains unclear. This may, in part, be due to the inherent difficulties in accurately assessing dietary intake on a large scale.

Existing technologies do not enable comprehensive objective measurement of diet (e.g. recovery biomarkers) at a population level, and, although this may change, current dietary assessment methods are based on self-report (i.e. subjective) measures such as food diaries or FFQ. Each of these assessment methods has strengths and limitations. Food diaries, which require individuals to record everything they consume over a period of time, are burdensome to the participant<sup>(1)</sup>. FFQ, which ask for a limited number of habitual food intakes generally over a 1-year period, are easy to administer but lack specificity for many nutrients<sup>(2,3)</sup>. Food recall measures, in which participants are asked to report everything they

consume, typically over a 24-h period, address many of these issues. Although dietary intake over a single 24-h period may be atypical of an individual's habitual dietary pattern, assessment of multiple 24-h food recalls over a period of time can be representative of habitual intake and can help assess seasonal variation in dietary intake<sup>(4)</sup>.

Traditionally, paper-based questionnaires or computer-assisted personal interviews have been used to assess dietary intake. More recently, there is growing awareness of the advantage of using web-based tools<sup>(5)</sup>. They are convenient and easy to use for the participant and result in automatic data capture for study investigators<sup>(4)</sup>. At present, research teams worldwide are developing web-based dietary assessment tools<sup>(6)</sup>. However, evidence regarding the performance of these tools is still limited. A recent review of innovative technologies for measuring diet in nutritional epidemiology concluded that more research is crucial to investigate the validity of innovative

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dietary assessment technologies<sup>(7)</sup>. If acceptable to the public, repeat 24-h recalls could provide a valid and convenient representation of habitual intake in large population studies.

The Oxford WebQ is a simple computerised 24-h dietary assessment tool suitable for self-completion using the Internet. The validity of the Oxford WebQ has been previously assessed in relation to an interviewer-administered 24-h recall<sup>(8)</sup>. This study reports preliminary evidence on the acceptability of repeated web-based administration of the Oxford WebQ over a 16-month period.

## Methods

### Participants

UK Biobank is a major national prospective cohort study designed to study a wide range of exposures related to lifestyle, environment and genes and their association with disease<sup>(9)</sup>. A non-representative sample of over 500 000 UK volunteers aged 40–69 years, identified through National Health Service records, was recruited between 2006 and 2010. Participants attended assessment centres throughout the UK to undergo extensive baseline measurements, with collection of blood, urine and saliva samples<sup>(10)</sup>. Participants gave their written consent for follow-up through access to medical and other records for health-related research purposes.

### Diet assessment

At recruitment, dietary intake was measured using a short self-completed FFQ different from the Oxford WebQ. This initial FFQ was designed to rank participants at baseline according to commonly eaten food groups, as well as seeking information about some common sources of various nutrients. However, it was recognised that this approach does not allow assessment of total energy intake or some specific nutrients. Therefore, this short FFQ was later supplemented by the administration of the Oxford WebQ to obtain more detailed nutrient-level information.

Similar to a 24-h dietary recall, the aim of the Oxford WebQ is to obtain information on the quantities of all foods and beverages consumed over the previous day. Unlike standard diet recall tools, however, the respondents are not asked to remember and report what they have consumed. Instead, akin to a FFQ, the Oxford WebQ presents individuals with twenty-one food groups and requests them to indicate whether they consumed any of them over the previous day (e.g. Did you eat any bread or crackers yesterday?). A positive response to any of these questions results in the screen expanding to reveal a list of commonly consumed foods in the corresponding category. Respondents then need to select the amount of each food consumed using standard categories to indicate the amount consumed (e.g. two slices of bread), and for foods without a natural size (e.g. cheese) a portion size is specified as a 'serving' with a description of that particular serving size in the help section of the Oxford WebQ. Thus, the data collection approach used in the Oxford WebQ could be defined as a hybrid between a 24-h dietary recall and a FFQ.

Open-ended questions were generally avoided in the questionnaire so that replies could be coded automatically, although some free-text boxes are available for use when the options listed do not fit with what the participants have consumed. The Oxford WebQ also asks whether the previous 24-h period was a typical day or not and why and whether the participant routinely follows a special diet.

Overall, the Oxford WebQ contains over 200 individual food items. These items were chosen to encompass the major foods consumed in the UK, using information from population dietary surveys and pilot studies, and to address current hypotheses about certain foods and diseases<sup>(8)</sup>. The quantity of each food and beverage consumed during the previous 24 h is calculated by multiplying the assigned portion size of each food or beverage by the amount consumed. Energy and nutrient values of the reported food items are generated by multiplying the quantity of each food or drink consumed by its nutrient composition, as taken from *McCance and Widdowson's The Composition of Foods* and its supplements<sup>(11–21)</sup>. The majority of portion sizes were taken from *Food Portion Sizes*<sup>(22)</sup>.

The Oxford WebQ was developed by repeated testing until none or very few items had to be entered as free text by participants<sup>(8)</sup>. As an initial evaluation study, 116 volunteers were asked to complete the Oxford WebQ immediately before completing a standard interviewer-administered 24-h recall and the results were compared. The mean differences in intake were less than  $\pm 10\%$  for all nutrients (e.g. 0.1 for energy,  $-1.3$  for protein, 4.6 for total fat,  $-3.4$  for total sugars) except for carotene ( $-23.6$ ) and vitamins B<sub>12</sub> (43.5) and D (18.3). Completing the Oxford WebQ took a median of 12.5 min, whereas the 24-h recall took 30 min to complete and 30 min to code.

### Procedure

The Oxford WebQ was included at the assessment visit as part of the baseline measures for the last 70 724 participants. It was also administered over the Internet to all UK Biobank participants with a known email address, who were invited to complete the Oxford WebQ on four separate occasions over a 16-month period.

For each of the four rounds, email invitations were sent on variable days of the week to the same person in order to capture changes in dietary intake between the working week and the weekend. Participants were encouraged to complete the questionnaire on the day of invitation, although they were allowed 3 d to complete the questionnaire for the first and second rounds of email invitations, after which time the link expired. This was extended to 14 d for the third and fourth rounds of email invitations to provide more time to complete the questionnaire, although the participants were still encouraged to complete it on the day of invitation. Participants did not receive incentives or reminders to complete the questionnaire.

Acceptability of the Oxford WebQ was assessed by rates of questionnaire completion. Statistical analyses were performed comparing age, sex, ethnic background, deprivation scores and education between Oxford WebQ responders and non-responders. Response rates by time of completion and



number of occasions are shown. Finally, an overview of the respondents' estimated nutrient intake by sex is provided.

### Results

A total of 211 053 participants completed the Oxford WebQ, either at the recruitment assessment clinics or via the Internet. Oxford WebQ responses at the assessment clinics were excluded from the analyses presented below.

In total, 331 013 participants (approximately 66% of the cohort) provided a valid email address and were invited to complete the Oxford WebQ online on four occasions between February 2011 and June 2012 (Fig. 1). Of the 331 013 invited participants, 176 012 (53%) completed the online version of the Oxford WebQ at least once. Of the 176 012 respondents, 115 447 (66%) completed the Oxford WebQ more than once. The response rate for any one round of invitations varied between 34 and 26%, being significantly lower during the summer months ( $P < 0.001$ ).

Compared with non-responders, participants who completed the online Oxford WebQ at any time were significantly more likely to be women, older, of white ethnic background, less deprived and more educated ( $P$  for all  $< 0.001$ ). Participants who responded on multiple occasions were also more likely to be white, older and more educated than those who only completed it once (Table 1).

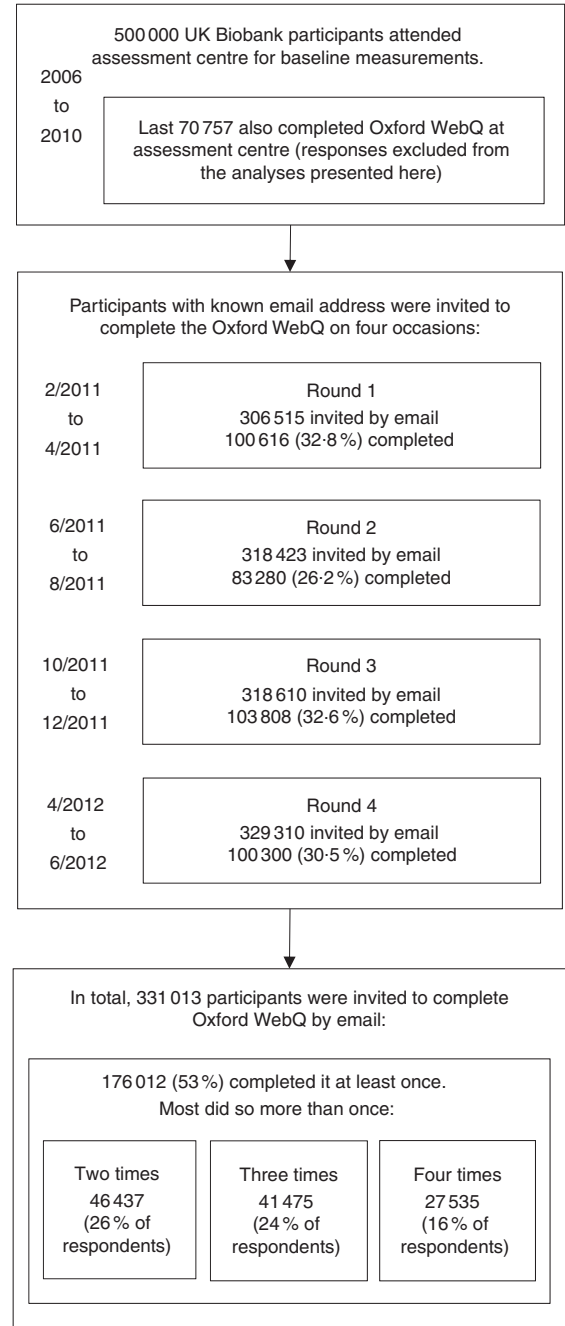
On most occasions, the Oxford WebQ was completed on the same day that they received the invitation (58% overall for all rounds combined), although for later rounds the likelihood of same-day completion declined (Fig. 2). Among all, 78% of the participants completed the Oxford WebQ on the same day as the invitation if it was received on a weekday, compared with 23% if received at the weekend. Most participants completed the Oxford WebQ in the morning both on weekdays and weekends (Fig. 3).

An overview of the respondents' estimated nutrient intake by sex is provided in Table 2. For participants who completed the Oxford WebQ more than once, their mean nutrient intake was calculated. The median total energy intake for men was 9293.5 kJ, of which an estimated 48.6% was carbohydrates, 32.2% was fats and 15.4% was protein. For women, the median total intake was 8030.4 kJ, of which an estimated 49.6% was carbohydrates, 32.7% was fats and 16.2% was protein.

### Discussion

This study found preliminary evidence that Internet-based administration of the Oxford WebQ is acceptable to the public. Overall, most participants (53% of those invited) completed the online version of the Oxford WebQ at least once, and most of them (66% of the respondents) did so more than once.

However, only 16% completed the questionnaire four times, showing a rapid decay with increased repetition. Participant fatigue, even in highly motivated samples, needs to be taken into account when planning the number and density of dietary assessment repetitions. Increasing the gap between repeat measurements may help keep response rates high. Other timing



**Fig. 1.** Study flow chart and Oxford WebQ response rates. The number of participants invited by email varied according to the number of valid emails available on each round.

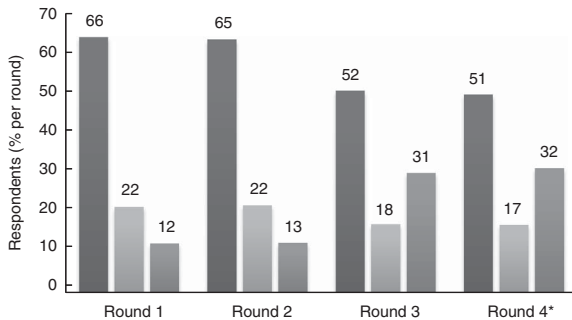
issues also affect rates: should it be necessary to collect dietary information during weekends or holiday periods, lower completion rates and increased delays are to be anticipated. Giving participants more time to complete the questionnaire reduced same-day completion rates and did not improve overall completion rates.

Compared with the rest of UK Biobank volunteers, those who completed the Oxford WebQ tended to be white, female, slightly older, less deprived and more educated, which is typical

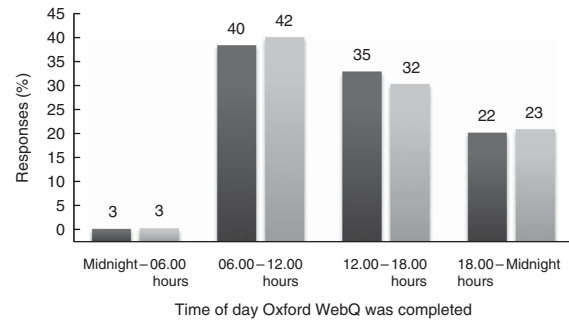
**Table 1.** Respondents' characteristics according to the number of times they have completed the Oxford WebQ (Numbers and percentages)

Number of times...	0 (non-responders)		1		2		3		4		Total	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
<b>Sex*</b>												
Females	80 060	52	32 925	54	25 824	56	23 305	56	15 303	56	177 417	54
Males	74 941	48	27 640	46	20 613	44	18 170	44	12 232	44	153 596	46
<b>Age in 2011* (years)</b>												
<49	29 771	19	10 710	18	7826	17	6353	15	3765	14	58 425	18
50–59	50 204	32	19 674	32	15 218	33	13 282	32	8639	31	107 017	32
60–69	63 127	41	25 723	42	20 133	43	19 025	46	13 183	48	141 191	43
Over 70	11 899	8	4458	7	3260	7	2815	7	1948	7	24 380	7
<b>Ethnicity*</b>												
White	143 974	93	57 638	95	44 744	96	40 140	97	26 835	97	313 331	95
Other	10 261	7	2734	5	1546	3	1184	3	602	2	16 327	5
Unknown	766	0	193	0	147	0	151	0	98	0	1355	0
<b>Deprivation score*</b>												
1 (least deprived)	32 830	21	13 590	22	10 373	22	9259	22	6092	22	72 144	22
2	32 180	21	13 154	22	9904	21	8902	21	5789	21	69 929	21
3	31 759	20	12 254	20	9610	21	8272	20	5780	21	67 675	20
4	30 902	20	11 864	20	9220	20	8317	20	5489	20	65 792	20
5 (most deprived)	27 330	18	9703	16	7330	16	6725	16	4385	16	55 473	17
<b>Education*</b>												
College or university degree	62 103	40	28 374	47	23 540	51	21 726	52	14 585	53	150 328	45
NVQ or HND or HNC or equivalent	24 264	16	8516	14	6059	13	5105	12	3200	12	47 144	14
A levels/AS levels or equivalent	4892	3	2060	3	1613	3	1430	3	982	4	10 977	3
O levels/GCSEs or equivalent	41 845	27	15 908	26	11 835	25	10 533	25	7003	25	87 124	26
None of the above	20 093	13	5395	9	3228	7	2556	6	1695	6	32 967	10
Unknown	1804	1	312	1	162	0	125	0	70	0	2473	1

NVQ, National Vocational Qualification; HND, Higher National Diploma; HNC, Higher National Certificate; AS, Advanced Subsidiary; GCSE, General Certificate of Secondary Education. \* *P* for difference between responders and non-responders <0.001 (demographic characteristics were compared between responders and non-responders using  $\chi^2$  tests).



**Fig. 2.** Number of participants who completed the Oxford WebQ by day of response for each round. \* Date data is missing for thirty-three participants. ■, Same day; □, next day; ▒, later.



**Fig. 3.** Time of day the Oxford WebQ was completed on weekdays and weekend days. Date data is missing for thirty-three participants. ■, Weekend; □, weekday.

of health-conscious volunteer-based studies. At the same time, UK Biobank participants are a non-representative sample: on average less deprived, better educated and under-represented in unskilled occupations than the national population<sup>(23)</sup>. This makes this Oxford WebQ sample highly selected, and therefore not suitable for analyses that require samples to be representative. However, the sample still shows sufficiently large numbers of participants with different levels of potential risk factors, allowing for generalisable associations between baseline characteristics and subsequent health outcomes to be made<sup>(10,24)</sup>.

A comparison of our respondents' estimated nutrient intake with the National Diet and Nutrition Survey<sup>(25)</sup> shows that values are within the expected normal range except for energy

intake (specifically from carbohydrate and SFA), which is somewhat higher in UK Biobank participants compared with national age- and sex-matched survey data. This might be reflecting the different data collection methods and/or the unrepresentative nature of the UK Biobank cohort.

Studies in various areas of health research have shown that traditional epidemiological risk factors can be collected with equal or even better reliability over the Internet compared with traditional approaches<sup>(26)</sup>. Response rates to web questionnaires have been found to be comparable with paper-based versions, at least in settings where the population generally has good access to the Internet<sup>(27,28)</sup>. Although participants with higher socio-economic indicators were more likely to respond, these trends were small (with highly significant *P* values

**Table 2.** Respondents' estimated nutrient intake based on 24-h dietary recall according to responses from the Oxford WebQ (Medians and interquartile ranges)

Nutrients	Men		Women	
	Median	Interquartile range	Median	Interquartile range
Total energy intake (kJ)	9293.0	7792.8–11 002.5	8030.1	6763.1–9442.1
Carbohydrates (% energy)	48.6	43.0–54.0	49.6	44.2–54.7
Starch (g)	131.9	103.4–162.0	109.4	84.9–135.4
Total sugars (g)	118.9	90.7–151.8	110.2	84.8–139.9
Fats (% energy)	32.2	27.9–36.4	32.7	28.3–36.9
PUFA (% energy)	5.6	4.3–7.1	5.8	4.4–7.4
SFA (% energy)	12.3	10.1–14.5	12.4	10.3–14.6
Protein (% energy)	15.4	13.5–17.6	16.2	14.1–18.5
Alcohol (% energy)	4.5	0–10.2	2.3	0–6.8
Ca (mg)	964.2	764.5–1200.0	905.6	718.4–1122.4
Carotene (µg)	2302.1	1128.4–3900.9	2760.0	1479.3–4459.2
Englyst dietary fibre (g)	15.9	12.2–20.3	15.5	12.0–19.5
Folate (µg)	302.1	240.8–375.2	277.9	221.2–345.3
Fe (mg)	14.2	11.5–17.1	12.7	10.4–15.3
Mg (mg)	356.1	295.2–425.6	323.9	269.2–384.5
K (mg)	3747.7	3090.8–4486.9	3555.6	2937.5–4247.0
Retinol (µg)	309.7	200.2–437.0	282.0	186.9–397.1
Vitamin B <sub>12</sub> (µg)	5.6	3.8–8.4	5.4	3.5–8.1
Vitamin B <sub>6</sub> (mg)	2.2	1.8–2.7	2.0	1.6–2.5
Vitamin C (mg)	126.9	76.7–191.7	135.2	85.6–200.6
Vitamin D (µg)	2.2	1.3–3.8	2.0	1.1–3.6
Vitamin E (mg)	8.5	6.2–11.4	8.7	6.5–11.4

reflecting the large sample size) and may be more dependent on patterns of use rather than on Internet access<sup>(29)</sup>.

Internet-based studies bear some advantages over their offline equivalents. The investment that is required for an online study tends to be lower, mostly due to low marginal costs<sup>(28)</sup> and Internet-based recruitment greatly increases geographic and demographic reach<sup>(30)</sup>. Moreover, owing to computerised display methods and automated data capture techniques, Internet-based studies avoid the errors associated with manual entry or optical scanning data entry techniques. Finally, the lack of face-to-face contact makes some people feel more comfortable to participate in Internet-based studies and respond more honestly<sup>(26,31)</sup>.

Both the validity of the Oxford WebQ for obtaining energy and nutrient values and its acceptability among members of the public for repeated remote testing need to be confirmed in future studies. However, preliminary evidence indicates that the Oxford WebQ may be a powerful tool for dietary assessment in large population-based studies.

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