Title Page

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

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Abstract

Although dietary intake over a single 24 hour period may be atypical of an individual's habitual pattern, multiple 24-hour dietary assessments can be representative of habitual intake and help to assess seasonal variation. Web-based questionnaires are convenient for the participant and result in automatic data capture for study investigators. This paper reports on the acceptability of repeated web-based administration of the Oxford WebQ, a 24-hour 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 e-mail 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-hour dietary assessment via the Internet is acceptable to the public and a feasible strategy for large population-based studies.

Introduction

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 food-frequency questionnaires. 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 [(1)]. Food-frequency questionnaires, 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 [(2; 3)]. Food recall measures, in which a participant is asked to report everything they consume, typically over a 24 hour period, addresses many of these issues. Although dietary intake over a single 24 hour period may be atypical of an individual's habitual dietary pattern, assessment of multiple 24-hour food recalls over a period of time can be representative of habitual intake and can help to assess seasonal variation in dietary intake [(4)].

Traditionally, paper-based questionnaires or computer assisted personal interviews have been used to assess dietary intake. More recently, there is a growing awareness of the advantage of using web-based tools [(5)]. They are convenient and easy to use for the participant and result in automatic data capture for study investigators [(4)]. Currently, research teams worldwide are developing web-based dietary assessment tools [(6)]. However, evidence of 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 dietary assessment technologies [(7)]. If acceptable to the public, repeat 24-hour recalls could provide a valid and convenient representation of habitual intake in large population studies.

The Oxford WebQ is a simple computerised 24-hour dietary assessment tool suitable for self-completion using the internet. The validity of the Oxford WebQ had been previously assessed in relation to an interviewer-administered 24-hour recall [(8)]. This paper reports preliminary evidence on the acceptability of repeated web-based administration of the Oxford WebQ over a 16-month period.

Experimental 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 [9]. A non-representative sample of over 500,000 UK volunteers aged 40-69 years, identified through NHS records, was recruited between 2006 and 2010. Participants attended assessment centres throughout the UK to undergo extensive baseline measurements, with collection of blood, urine & saliva samples [10]. Participants gave 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 food-frequency questionnaire different from the Oxford WebQ. This initial food-frequency questionnaire 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 food-frequency questionnaire was later supplemented by the administration of the Oxford WebQ to obtain more detailed nutrient level information.

Similar to a 24-hour 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 respondent is not asked to remember and report what they have consumed. Instead, akin to a food-frequency questionnaire, the Oxford WebQ presents individuals with 21 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-hour dietary recall~~s~~ and a food frequency questionnaire~~s~~.

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 hour 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 [8]. The quantity of each food and beverage consumed during the previous 24-hours 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 [11; 12; 13; 14; 15; 16; 17; 18; 19; 20; 21]. The majority of portion sizes were taken from *Food portion sizes* [22].

The Oxford WebQ was developed by repeated testing until none or very few items had to be entered as free text by participants [8]. As an initial evaluation study, 116 volunteers were asked to complete the Oxford WebQ immediately before completing a standard interviewer-administered 24-hour recall and results were compared. The mean differences in intake were less than +/-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 B12 (43.5) and D (18.3). Completing the Oxford WebQ took a median of 12.5 minutes, while the 24-hour recall took 30 minutes to complete and 30 minutes 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 e-mail address, who were invited to complete the Oxford WebQ on four separate occasions over a 16 month period.

For each of the four rounds, e-mail 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 three days to complete the questionnaire for the first and second rounds of e-mail invitations, after which time the link expired. This was extended to 14 days for the third and fourth rounds of e-mail 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, gender, ethnic background, deprivation scores and education between Oxford WebQ responders and non-responders. Responses 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 (~66% of the cohort) provided a valid e-mail address and were invited to complete the Oxford WebQ online on four occasions between February 2011 and June 2012 (Figure 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 to non-responders, participants who completed the online Oxford WebQ at any time were significantly more likely to be women, older, 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 (Figure 2). 78% of 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 (Figure 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 (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 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 to 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 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 [23]. This makes this Oxford WebQ sample highly selected, therefore not suitable for analyses which 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 [10; 24].

A comparison of our respondents' estimated nutrient intake with the National Diet and Nutrition Survey[25] shows that values are within the expected normal range except for energy intake (specifically from carbohydrate and saturated fat), which is somewhat higher in UK Biobank participants compared to 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 epidemiologic risk factors can be collected with equal or even better reliability over the Internet compared with traditional approaches [26]. Response rates to web questionnaires have been found to be comparable to paper-based versions, at least in settings where the population generally has good access to the Internet [27] [28]. Although participants with higher socio-economic indicators were more likely to respond, these trends were small (with highly significant p-values reflecting the large sample size) and may be more dependent on patterns of use rather than on Internet access [29].

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 [28] and Internet-based recruitment greatly increases geographic and demographic reach [30]. Moreover, due 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 [26; 31].

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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Conflict of Interest

None.

Authorship

Julieta Galante: analysed the data and wrote the article.

Ligia Adamska: analysed the data and wrote the article.

Alan Young: collected the data.

Heather Young: processed the data.

John Gallacher: designed the study and wrote the article.

Thomas Littlejohns: analysed the data and wrote the article

Naomi Allen: formulated the research questions, designed the study, carried it out, analysed the data and wrote the article.

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Tables

Table 1. Respondents' characteristics according to the number of times they have completed the Oxford WebQ.

Number of times (n (%)):	0 (non-responders)	1	2	3	4	Total
Gender*						
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)
Age in 2011*						
< 49	29,771 (19)	10,710 (18)	7,826 (17)	6,353 (15)	3,765 (14)	58,425 (18)
50-59	50,204 (32)	19,674 (32)	15,218 (33)	13,282 (32)	8,639 (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)	4,458 (7)	3,260 (7)	2,815 (7)	1,948 (7)	24,380 (7)
Ethnicity*						
White	143,974 (93)	57,638 (95)	44,744 (96)	40,140 (97)	26,835 (97)	313,331 (95)
Other	10,261 (7)	2,734 (5)	1,546 (3)	1,184 (3)	602 (2)	16,327 (5)
Unknown	766 (0)	193 (0)	147 (0)	151 (0)	98 (0)	1,355 (0)
Deprivation score*						
1(least deprived)	32,830 (21)	13,590 (22)	10,373 (22)	9,259 (22)	6,092 (22)	72,144 (22)
2	32,180 (21)	13,154 (22)	9,904 (21)	8,902 (21)	5,789 (21)	69,929 (21)
3	31,759 (20)	12,254 (20)	9,610 (21)	8,272 (20)	5,780 (21)	67,675 (20)
4	30,902 (20)	11,864 (20)	9,220 (20)	8,317 (20)	5,489 (20)	65,792 (20)
5(most deprived)	27,330 (18)	9,703 (16)	7,330 (16)	6,725 (16)	4,385 (16)	55,473 (17)
Education*						
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)	8,516 (14)	6,059 (13)	5,105 (12)	3,200 (12)	47,144 (14)
A levels/AS levels or equivalent	4,892 (3)	2,060 (3)	1,613 (3)	1,430 (3)	982 (4)	10,977 (3)
O levels/GCSEs or equivalent	41,845 (27)	15,908 (26)	11,835 (25)	10,533 (25)	7,003 (25)	87,124 (26)
None of the above	20,093 (13)	5,395 (9)	3,228 (7)	2,556 (6)	1,695 (6)	32,967 (10)
Unknown	1,804 (1)	312 (1)	162 (0)	125 (0)	70 (0)	2,473 (1)

* p for difference between responders and non-responders < 0.001 (demographic characteristics were compared between respondents and non-respondents using $\chi 2$ tests.)

Table 2. Respondents' estimated nutrient intake based on 24 hour dietary recall according to responses from the Oxford WebQ.

Nutrient	Men Median (Interquartile range)	Women Median (Interquartile range)
Total energy intake (kJ)	9293.0 (7792.8-11002.5)	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)
Polyunsaturated fat (% energy)	5.6 (4.3-7.1)	5.8 (4.4-7.4)
Saturated fat (% 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)
Calcium (mg)	964.2 (764.5-1200.0)	905.6 (718.4-1122.4)
Carotene (ug)	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 (ug)	302.1 (240.8-375.2)	277.9 (221.2-345.3)
Iron (mg)	14.2 (11.5-17.1)	12.7 (10.4-15.3)
Magnesium (mg)	356.1 (295.2-425.6)	323.9 (269.2-384.5)
Potassium (mg)	3747.7 (3090.8-4486.9)	3555.6 (2937.5-4247.0)
Retinol (ug)	309.7 (200.2-437.0)	282.0 (186.9-397.1)
Vitamin B12 (ug)	5.6 (3.8-8.4)	5.4 (3.5-8.1)
Vitamin B6 (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 (ug)	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)

Figures

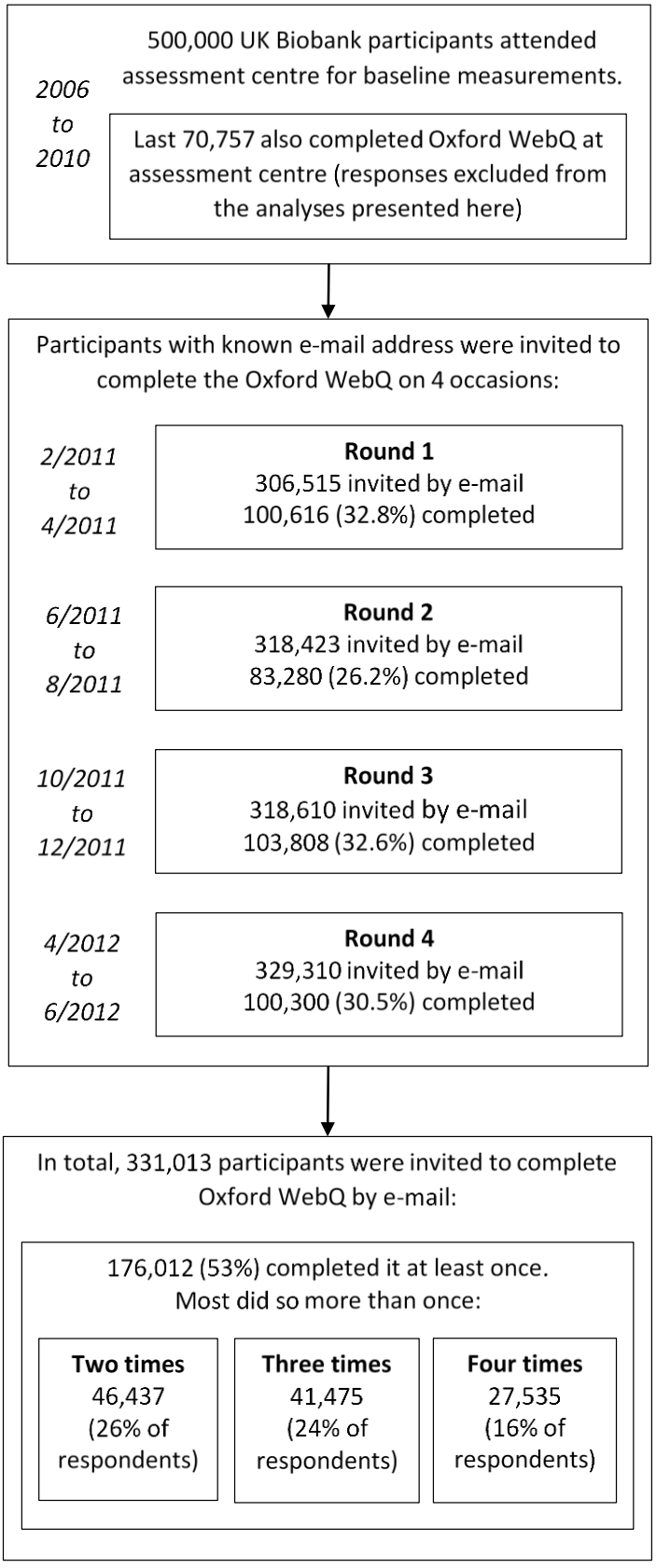

Figure 1. Study flowchart and Oxford WebQ response rates. The number of participants invited by e-mail varied according to the number of valid e-mails available on each round.

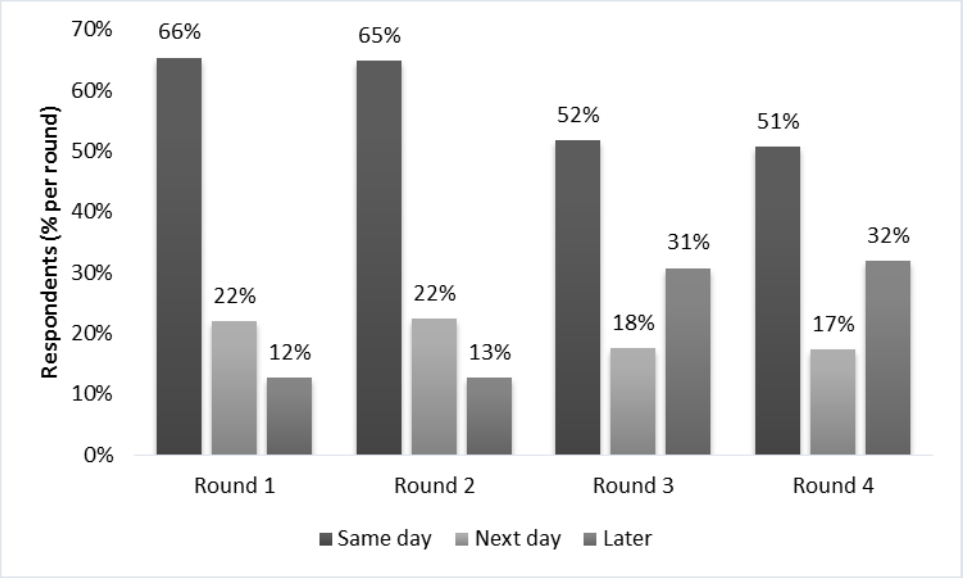

Figure 2. Number of participants who completed the Oxford WebQ by day of response for each round. Date data is missing for 33 participants.

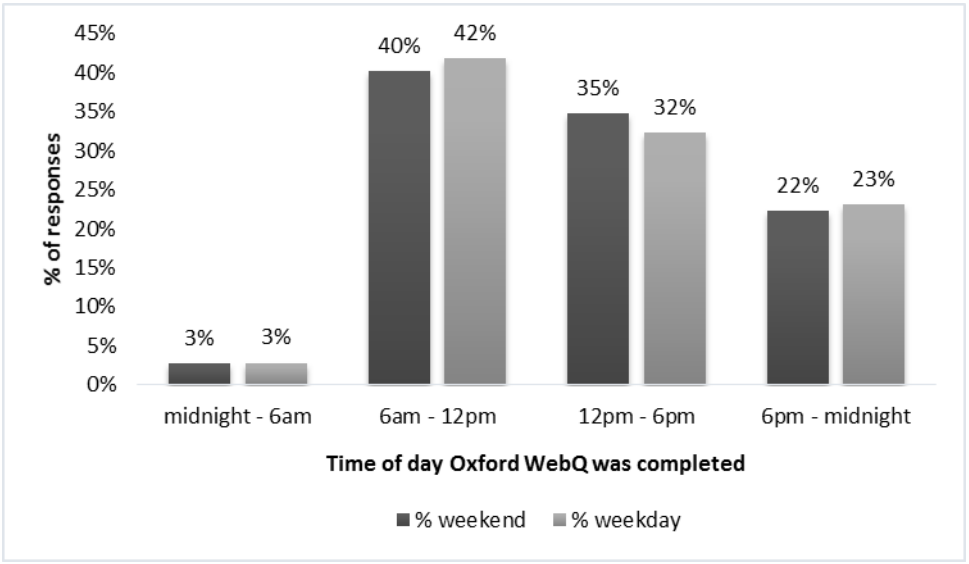

Figure 3. Time of day the Oxford WebQ was completed on weekdays and weekend days. Date data is missing for 33 participants.