Record or Recall? Exploring Self-Reported Dietary Assessment Methods for Office Workers during the COVID-19 Work-from-Home Period

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ABSTRACT

The workplace represents an important venue to influence eating behaviors. Due to the COVID-19 pandemic, the workplace has rapidly shifted from office to home (WfH). Here, two mobile self-reported dietary assessment methods were compared (4-hour Recall vs. Food Record) to monitor food intake for WfH. A within-subject study involving 30 participants was conducted over a 4-week period. We assessed the workload and acceptance of these two methods using questionnaires and follow-up interviews. Results of questionnaires revealed that most participants presented high acceptance of Food Record related to a more flexible completion time and lower mental burden. Based on interviews, we presented a set of design insights to promote WfH healthy eating, including integrating reminders into daily routines, simplifying the tracking process, and adding gaming elements. Then, we discussed design implications, including integrating digital tools into daily routines and designing simple and playful using processes, to promote healthy eating during the WfH period.

CCS CONCEPTS

• **Human-centered computing**; • **Human computer interaction (HCI)**; • **HCI design and evaluation methods**; • **User studies**;

KEYWORDS

Healthy eating, Work from home, Digital technology, Dietary assessment

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NordiCHI '22, October 08–12, 2022, Aarhus, Denmark

ACM ISBN 978-1-4503-9699-8/22/10.
https://doi.org/10.1145/3546155.3546649

ACM Reference Format:
Sibo Pan, Elske M. Brouwer-Brolsma, Xipei Ren, Steven Vos, Aarnout Brombacher, and Desiree A. Lucassen. 2022. Record or Recall? Exploring Self-Reported Dietary Assessment Methods for Office Workers during the COVID-19 Work-from-Home Period. In *Nordic Human-Computer Interaction Conference (NordiCHI '22), October 08–12, 2022, Aarhus, Denmark*. ACM, New York, NY, USA, 12 pages. https://doi.org/10.1145/3546155.3546649

1 INTRODUCTION

In the Netherlands, full-time office workers (i.e., >36 hours/workweek) commonly spend eight hours per day at work with various eating-related activities (lunching, snacking, etc.) integrated into their work routines [37]. However, studies indicate that – 66-91% of the office workers experience that long working hours and tight schedules are associated with reduced attention for (healthy) eating behaviors, such as food choices and irregular eating times/breaks [44]. In the short term, a poor diet may affect employees' concentration, mood, and productivity [39, 48, 84], whereas in the long term, unhealthy eating behaviors have been associated with the development of overweight, obesity, and a higher risk of chronic diseases [61].

As the greater availability of high-speed Internet have developed, remote working in various contexts (i.e., office, home, other working location) has grown as a new working mode in the past several decades [4]. But such working mode was an optional practice before the Covid-19 pandemic [41]. During the Covid-19 pandemic, the World Health Organization suggested that working-from-home (WfH) as one approach of remote working mode should be implemented around the world to prevent the spread of the virus. Therefore, almost one-third of the global population is in a lockdown situation [22]. In Europe, the lockdown regulations resulted in a rapid shift from working in the office to WfH [42]. However, many office workers had to switch, quite suddenly, to work from home for the first time and without any preparation [28] and lack of enough skills required for remote work, such as time planning skill and work-life balance [24, 79]. To face these challenges, Sandra et al. [49] suggested creating regular daily routines such as eating

at the same time every day, making solid working routines, etc. Also, setting reminders might be helpful to build these actions into a habit after weeks of routine [43]. By having regular routines, previous studies have shown that working-age individuals could decrease the risk of having mental or metabolic disorders [52]. Recently, WfH is a compulsory policy rather than a discretionary option. Understanding the potential advantages and risks of work itself in WfH context is imperative and could affect working-age individuals' happiness, work satisfaction, and work-life balance [19, 69].

By contrast, some research studies showed that the COVID-19 lockdown has contributed to unhealthy eating behaviors, including increased consumption of unhealthy foods, larger portions sizes during main meals, more snacks between meals [6]. Specifically, during the lockdown and WfH period, people should have had more time to cook and organize their meals [70]. But limited access to daily shopping stores and heavy working tasks may reduce fresh food consumption (especially fruits, vegetables, and fish) and increase the choice of convenience foods, junk foods, and ready-to-eat foods with high fat, sugars, and salt [70]. Moreover, current studies on lockdown eating patterns revealed a shift in self-reported eating towards increased overall food consumption and increased snacking in-between meals [6, 73]. According to some other studies [55, 64], this shift may raise by the boredom from interruption of the work routine at home or the stress from working tasks without a break. Although healthy eating behaviors are essential during the lockdown and WfH period, only a couple of studies or research have recently focused on improving eating routines and behaviors. For instance, the World Health Organization (WHO) offered food and nutritional tips during the lockdown period [27]. A Spanish study [71] found that providing a healthy diet to study groups could decrease the intake of fried foods, snacks, fast foods, or sweet beverages, but increase vegetables, fruits, or legumes during the confinement. Therefore, understanding eating behaviors and promoting healthy eating routines at home should be identified as an important research gap for the lockdown and work-from-home period.

Moreover, regarding technology-based dietary assessment methods, self-reported methods of recall and record are the most common used approaches to subjectively assess dietary intake [12]. In recent decades, more and more mobile applications are designed to facilitate self-report and daily nutrition tracking for the everyday context. For example, MyFitnessPal [57] and FatSecret [25] allow users to scan barcodes to determine food intake and portion size. Lee et.al [45] developed a mobile application called Diet-A for recording dietary intake, real-time feedback, and provision of information on disease prevention. Eat&Tell [1] is a mobile application designed to facilitate the collection of eating-related data through automated tracking and self-report. Although these digital technologies have focused on tracking food consumption and improving eating behaviors, less attention has been paid on promoting healthy eating behaviors and routines during working hours in the context of WfH. Thus, more attention should be paid to first understand which is a better accepted self-reported dietary assessment method during WfH period for working individuals.

In this study, a within-subject study has been conducted to compare two smartphone-based self-reported dietary assessment methods (namely: 4-hour Recall vs. Food Record) to monitor food intake during WfH period. The 4-hour Recall method invites participants to report their food intake over the previous 4-hour, and with the Food Record method, participants can report their food intake throughout the day. The main contribution of this study is to compare the acceptance of these two methods, which method can help working individuals to gain healthy eating behaviors and routines in WfH context and develop design opportunities for digital tools to stimulate healthy eating during working hours. This study is designed to answer the following two research questions:

- **RQ1**: Whether the 4-hour Recall method is more effective in terms of workload and acceptance than the Food Record method in supporting working individuals to record food intake?
- **RQ2**: What are the design opportunities of a self-reported digital tool to stimulate working individuals to change their eating behaviors during WfH period?

2 RELATED WORK

2.1 Self-reported Dietary Assessment Methods

Self-reported dietary assessment methods are commonly used to assess dietary intake. Self-reported dietary assessment can be roughly divided into two categories: prospective methods (i.e., food record) and retrospective methods (e.g., dietary recall, food frequency questionnaires) [58]. According to previous review [60], diet recall and food report have been the most often applied self-reported assessment methods for daily intake. Regarding diet recall, it is a method to generate detailed food consumption during the setting period (e.g., 2-4 hours recall, 24hours recall) and gain insight in the habitual intake [12]. Regarding food report, it is a real-time monitoring approach to gain detailed amount of food consumption during the recording period (e.g., a single day) [12].

With the development of digital tools, mobile technologies such as smartphone applications (i.e., apps) have become widely available [47]. Diet recall and food record have slowly shifted from paper-pencil based towards technology-based tools in the past decade [17]. For instance, Compl-eat^{TM} [54] is a Dutch web-based dietary recall tool, which contains an extensive food list and could be easily modified and tailored for specific research needs. FoodLog [3] is a food recording system that allows users to transfer food images into literal reports with the assistance of image retrieval on their smartphones. Evidence showed that the collection of dietary reports via mobile technologies has a potential to be more convenient than paper-based reporting [36] and have a greater possibility for the purpose of stimulating healthy eating behaviors [83].

However, current dietary assessment methods are normally designed for specific settings and populations. For instance, some are developed to assess children and adolescents' dietary intake [8, 14, 62], some focused on helping overweight population to lose weight [13, 81], some others are mainly used for clinical practice among patients [29, 72]. Therefore, further dietary assessment methods should be adapted and validated whenever they are used in different settings (e.g., WfH, worksite, various cultural background) or populations (e.g., healthy individuals, different age group) [68].

2.2 Digital tools for Healthy Eating Promotion

In the HCI communities, research on healthy eating technologies has mainly focused on healthy eating promotion, including eating goal setting, awareness of healthy eating, feedback, social connectivity, etc. Pan and colleagues discovered [66] that mobile applications are often used as practical digital tools for encouraging healthy eating behaviors. Specifically, MyFitnessPal [57] supports healthy eating by relying on associating food ingredients with calories. By scanning QR coed on food packages, some mobile applications [32, 75] focused on encouraging healthy food choices and provide food-related feedbacks to users. Moreover, many digital technologies offering new opportunities to improve healthy eating behaviors have been proposed in the past decades. For instance, some devices are designed for tracking nutritional information while cooking in the kitchen. They could help users gain awareness of food consumption [15]. Some smart scales, such as Orange Chef [76], could integrate with a mobile app and provide real-time insight into nutrition as well as balanced meals. Furthermore, previous research has explored the social features as helpful approach to encourage behavior change. For example, Instagram [16], a social media and online community, could help users to achieve personal health eating goals. The mobile food journaling [51] could facilitate family support for healthy eating. Even in worksite, healthy eating behaviors enable to be stimulated by gamified social competitions [82]. This is in line with earlier findings by Pan et al. [65], which showed that the majority of people anticipated the promotion of healthy eating at work would be supported by the goal assistant, social influence, integration with physical program, and provision of food-related knowledge. Additionally, image-based digital tools [10, 59] has been proposed to simplify food reporting process recently, regarding of estimating nutrition content and portion sizes.

However, few studies were focused on specific using context (e.g., working context) with dietary digital tools. It also appears to be challenging, since little research has been done to investigate the adaptivity of digital tools for promoting healthy eating in WfH period. The evidence only shows a potential to integrate digital tools into specific using context like worksite. Thus, to understand using acceptance of digital tools in working context during WfH period is necessary for further development of mobile technologies, especially influenced by the Covid-19 pandemic.

3 THE STUDY

In this study, we used a dietary assessment app developed by researchers from Wageningen University and Research, called 'Traqq' [50]. As shown in Figure 1, Traqq is a flexible dietary assessment tool that facilitates both records and recalls and can be used to collect dietary intake data on one or more prespecified days. In this study, the app was used as a Food Record (i.e., users can enter their food intake throughout the day as shown in Figure 1(d)) and a 4-hour Recall (i.e., users are prompted to report their food intake during the previous 4 hours as shown in Figure 1(e)). By comparing these two methods, we would like to find an acceptable time interval (4-hour vs. all-day) that can help working individuals to stimulate healthy eating behaviors and routines in WfH context. The evaluation of user experience with Traqq focused on the task load and user acceptance of two dietary assessment methods during WfH period. Therefore, the NASA task load index (NASA-TLX) [31] and the Unified Theory of Acceptance and Use of Technology 2 questionnaire (UTAUT2) [78] were used as research tool for data collection.

In response to the research questions, the aim of this study is to 1) investigate and compare the effectiveness and user acceptance of two dietary assessment methods (i.e., 4-hour Recall and Food Record); and 2) explore design opportunities of mobile-based digital tools to stimulate healthy eating behaviors and routines among working individuals in the WfH context. Additionally, we were interested in exploring the user experience of each method to explore further design insights of improvement. According to the review of literatures, research questions, and aims of the study, our primary hypotheses are:

- **H01**: The 4-hour Recall method will be a more helpful self-reported dietary assessment tool in WfH context than the Food Record method.
- **H02**: The 4-hour recall method will be more effective in terms of workload and acceptance in helping participants record their food intake during working hours at home than the Food record method.

3.1 Participants

Thirty participants were recruited by spreading information via word of mouth, taking a snowball sampling approach, emails, and social media (Twitter, Facebook, and LinkedIn). To be eligible for inclusion in the study, participants need to meet the following criteria: 1) age between 18 and 65 years; 2) have been working in the Netherlands for more than six months and should be able to speak and read Dutch; 3) be engaged in full-time knowledge work for more than 6 hours a day, five days per week; 4) have a fixed working period every weekday in WfH context; 5) do not follow a special diet or dietary treatment. Every participant was fully informed of the study procedure with consent without discussing its hypotheses and was able to withdraw at any time. Each participant was compensated € 20 in the form of a digital gift voucher after completion of the study.

In total, 32 participants took part in the study. Two participants dropped out of the study in the middle of the process due to personal health status and working schedules. A total of 30 participants aged between 21 to 54 years (M = 31.07, SD = 7.62) finished the entire procedure. Ten participants were male (33.33%) and 20 were females (66.67%) and they had been working between 1 to 35 years in an office context (M = 9.41, SD = 9.81). Eighteen participants were Dutch, and 14 participants originated from 12 other countries, including UK (n=2), India (n=2), China (n=7), and Hungary (n=1). All participants were non-low-income knowledge worker and engaged in a job that requires desk/computer work between six to ten working hours per weekday (M = 7.43, SD = 0.77). On average, most participants worked from home for 4 days/week (Min = 2, Max = 5, M = 4.03). Ten participants lived alone, whereas 20 participants lived with families, partners, or friends.

3.2 Procedure

The study was carried out during the period between October 2020 and July 2021 in the Netherlands. For the study setup, we adopted

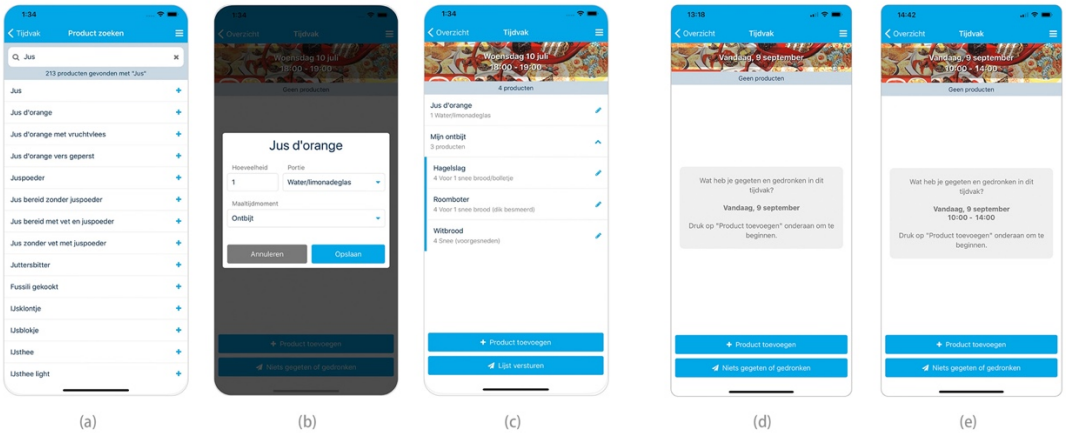

Figure 1: Interface of Traqq with functions: (a) selecting food items in the food list; (b) inserting portion size and mealtime; (c) overview of inserted food items and possibility to adjust input. Interface of Traqq with method: (d) Food Record method: report dietary intake throughout the day; (e) 4-hour Record method: report dietary intake over the previous 4-hour (notifications were sent at 10 am, 14 pm, 18 pm and 22 pm in this study).

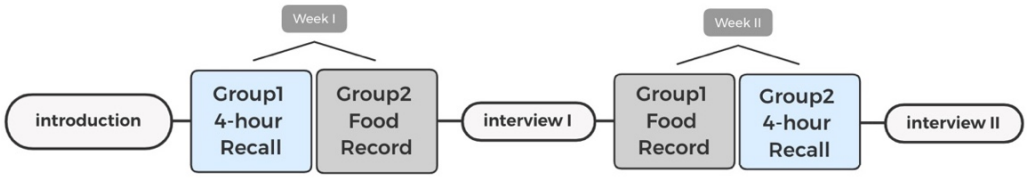

Figure 2: A visualization of overall study procedure.

a within-subject design, where the participants were randomly divided into two groups. As shown in Figure 2, the study was initiated by an online introductory session via Microsoft Teams to explain the procedure of the study without discussing the research hypotheses. Each participant was asked to fill out a screening questionnaire via Microsoft Form and signed the consent form. The screening questionnaire contained each participant's demographic information, working status, and living status during the WfH period. Afterward, the participants received an introduction with login credentials to access the app on their smartphones. During the study, participants were asked to report their dietary intake in the app for two full weeks, once via the 4-hour Recall method and once via the Food Record method, with one wash-out week in between.

3.2.1 Measurements. We collected both quantitative and qualitative data (Table 1). Quantitative data included results of NASA-TLX and UTAUT2. Qualitative data gained from follow-up interviews. More details about quantitative and qualitative measurements are explained in the following.

Participants received the NASA-TLX via email every evening in both weeks and had to fill out UTAUT2 after each week. We used NASA-TLX to assess the cognitive workload for both the 4-hour Recall method and the Food Record method. As we mainly focused on examining mental demands, three subscales of NASA-TLX were used in this study - *mental demands, performance, and frustration* - to indicate how burdensome the participants feel the dietary assessment method was. For each subscale, a lower rating represents a lower workload (1 is low, 21 is high), but in the case of performance, it represents being more satisfied with the performed task (1 is perfect, 21 is failure). The user acceptance of each method was measured by UTAUT2, which included 28 items across eight scales, including *performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, price value, habit, and behavioral intention.* As Traqq app was not designed for commercial purpose and we mainly focused on testing user acceptance of the 4-hour Recall method and the Food Record method, therefore, four scales (*facilitating conditions, hedonic motivation, habit, behavioral intention*) were included for further analysis process. Each

Table 1: Data collected from the study.

Measures	Week I								Week II								
	Day	1	2	3	4	5	6	7	Day	1	2	3	4	5	6	7	
User experience		√	√	√	√	√	√	√		√	√	√	√	√	√	√	
NASA-TLX								√									√
UTAUT2																	
Follow-up interview								√									√

Table 2: Interview pre-set protocol.

Question	Elaborative Question	Theory
1. What do you like/dislike about Food Record method/4-hour Recall method in the last week?	Does this method fulfil your needs? Why or why not?	TAM-usefulness [33]; Mobile App Rating Scale [74]
2. Are you satisfied with the time taken to track your intake on Traqq with Food Record method/4-hour Recall method?	(Prompts: during working hours/weekend) Does the notification(s) help you to remember to track? What factors influence your satisfaction about using Traqq in the last week?	Usability Risk Level Evaluation [38]
3. What benefits/disadvantages did you find from this method? What can be improved? How to improve?	-	-
4. What customization features about Food Record method/4-hour Recall method would you like to see on Traqq?	(Prompts: (un)desired functions/features)	Mobile App Rating Scale [74]

scale ranged from 1 (strongly agree) to 5 (strongly disagree), with 3 standing for neither agree nor disagree.

Additionally, the interviews collected qualitative data to identify user experience and further design opportunities of digital tools. After each week, we conducted an approximately 15 minutes follow-up interview to understand participants' experience and opinions of the 4-hour Recall method and Food Record during working hours, separately. Each interview followed a pre-set protocol and comprised open-ended questions based on the Technology Acceptance Model [21], the Mobile Application Rating Scale [74], and the Usability Risk Level Evaluation [38] (as shown in Table 2). We eliminated the same items among these three theoretical frameworks and selected items that suited our research objectives. To conclude the entire study, we asked participants some additional questions at the end of the second interview such as "*Which method of Traqq would you more consider using for your working hours in WfH context?*" "*Please describe the reason you like or dislike each mothed and share your ideas for improvement.*" and "*Do you have any suggestions concerning the use of Traqq to aid eating activities in your everyday work?*" There was enough space for participants to provide their feedback on their experience. We also asked the participants to explain some interesting statements that emerged during the interviews. Both follow-up interviews were audio-taped and transcribed later for qualitative analysis. The interview data was used to support the interpretation of the quantitative data.

3.3 Data Analysis

3.3.1 Quantitative Analysis. NASA-TLX responses and UTAUT2 questionnaire responses were also analyzed by SPSS. Firstly, the quantitative data was processed with descriptive statistics, in which the distribution of the NASA-TLX and UTAUTS data were checked through Shapiro–Wilk tests. For data with normality, we conducted Paired-Samples *t*-tests with the methods (4-hour Recall and Food Record) as a factor. For the data that was not normally distributed, we conducted a Wilcoxon Signed-ranks test to measure the difference between the two methods. The main objectives of our quantitative analyses were to 1) evaluate dietary intake quality of both Food Record reporting week and 4-hour Recall reporting week; 2) evaluate task load and user acceptance of two methods on Traqq in the WfH context. All statistical analyses were conducted using SPSS (SPSS, IBM Version 26; SPSS, Inc., Chicago, IL).

3.3.2 Qualitative Analysis. After each study week, an approximately 15 minutes follow-up interview with each participant were conducted to collect qualitative data. The results of the interviews were analyzed by MAXQDA software. The thematic analysis [11] following inductive coding [77] was used for data analysis with following steps: First, the segmentation of the transcripts was transformed into quote statements and was labeled. Then, the labeled statements were measured using affinity diagrams [40] to identify recurring clusters with emergent themes. Next, all identified themes and clusters were reviewed, discussed, and revised through several iterations with most the member of research team (the third,

Table 3: Mean values, standard error, and Wilcoxon Signed-ranks test results of NASA-TLX.

	Performance		Mental Demand		Frustration	
	4-hour Recall	Record	4-hour Recall	Record	4-hour Recall	Record
N	210	210	210	210	210	210
Mean	11.10	10.75	10.70	10.02	10.20	9.05
SE	0.38	0.40	0.34	0.32	0.39	0.33
p	.325		.049		.003	

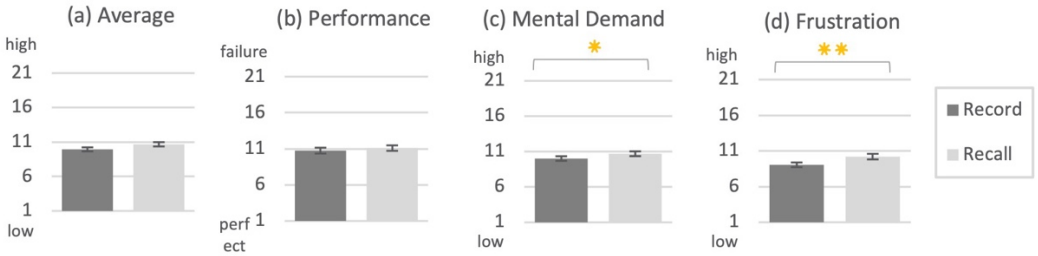

Figure 3: Mean and SE of NASA-TLX.

fourth and fifth co-authors) to validate the qualitative analysis. The purpose of the qualitative analysis was to gain insight about to use of digital tools to promote healthy eating, to find an adoptive assessment (4-hour Recall or Food Record) of working context, and to get more insights in design opportunities for digital tools and features.

4 RESULTS

4.1 Quantitative Analysis

4.1.1 NASA-TLX. The NASA-TLX was used to measure the daily workload of each dietary assessment method during the two individual weeks. Table 3 and Figure 3 show the results of the NASA-TLX. Participants finished the NASA-TLX over seven days each week with three subscales: *performance, mental demand, and frustration.* As shown in Figure 3 (a), the perceived load of using both methods scored low (1 is low, 21 is high), resulting from relatively high satisfaction with performance, and low levels of mental demand and frustration in all conditions. Participants rated the workload with the Food Record method (M = 9.94, SE = 0.29) significantly (p = 0.004) lower than with the 4-hour Recall method (M = 10.67, SE = 0.31).

Regarding the performance (shown in Figure 3 (b)), participants perceived a better experience in using the Food Record method (M = 10.75, SE = 0.40) than with the 4-hour Recall method (M = 11.10, SE = 0.38). A Wilcoxon Signed-ranks test indicated that there was no significant difference between the two methods (p = 0.325). Regarding the mental demand (shown in Figure 3 (c)), the 4-hour Recall method (M = 10.70, SE = 0.34) required a significantly (p = 0.049) higher cognitive load than the Food Record method (M = 10.02, SE = 0.32). Regarding the frustration (shown in Figure 3 (d)), we observed that participants' frustration with the Food Record method (M = 9.05, SE = 0.33) was significantly (0.003) lower than with the 4-hour Recall method (M = 10.20, SE = 0.39).

The analysis also showed that the fluctuation in the results of the 4-hour Recall method was relatively large. Specifically, if the participant missed a notification from the app (e.g., due to a busy working schedule), the score of the NASA-TLX for that day was relatively negative with low satisfaction with performance, and high levels of mental demand and frustration. Regarding the NASA-TLX scores during the Food Record week, we noticed a trend of scoring from pervasive low scores (with low satisfaction with performance, high level of mental demand, and frustration) at the beginning of the week to high scores (with high satisfaction with performance, low level of mental demand and frustration) at the end of the week. However, this trend was not significant.

4.1.2 UTAUT2. The data of UTAUT2 was collected at the end of each individual week, which aimed to indicate the user acceptance of the 4-hour Recall method and Food Record method. Table 4 and Figure 4 show the results of the UTAUT2. Overall, we found that participants were slightly more motivated to use the Food Record method (M = 3.26, SE = 0.10) compared to the 4-hour Recall method (M = 3.36, SE = 0.10) in the WfH context. Specifically, participants had a more positive attitude toward the facilitating conditions to use the Food Record method (M = 2.33, SE = 0.10) in a WfH context more than with the 4-hour Recall method (M = 2.68, SE = 0.18). However, they presented disagreements regarding hedonic motivation, habit, and behavioral intention for each method. Additionally, a Paired-Samples t-test showed that there were no statistical differences between the two methods for the subscales of *facilitating conditions* (t (29) = -1.615, p = 0.117), *hedonic motivation* (t (29) = -0.328, p = 0.745), *habit* (t (29) = -0.282, p = 0.780), *and behavioral intension* (t (29) = -0.885, p = 0.383).

Table 4: Mean values, standard error, and Paired-Samples t-test results of UTAUT2.

	Facilitating conditions		Hedonic motivation		Habit		Behavioral intension	
	4-hou Recall	Record	4-hou Recall	Record	4-hou Recall	Record	4-hou Recall	Record
N	30	30	30	30	30	30	30	30
Mean	2.33	2.68	3.90	3.97	3.93	3.98	4.01	4.18
SE	0.10	0.18	0.16	0.18	0.10	0.12	0.14	0.13
t	-1.615		-.328		-.282		-.885	
p	.117		.745		.780		.383	

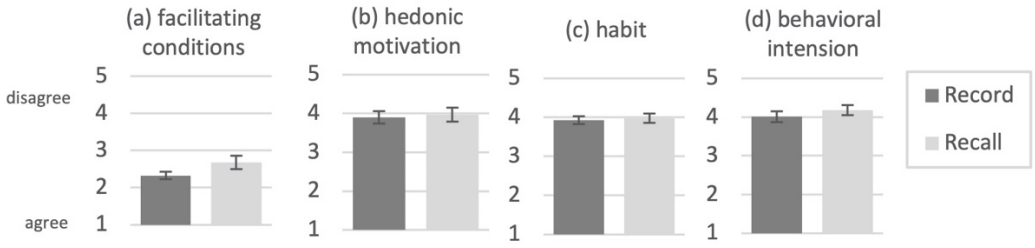

Figure 4: Mean and SE of UTAUT2.

Table 5: Interview findings of preferred method.

Keyword	Method	Theme	Frequency	Exemplar Quotations
Using experience	4-hour Recall	Well-structured reminders	19	"*The setting of these four notifications is reasonable and can be integrated into my working routine perfectly.*"
		Excessive reminder settings	42	"*I feel stressed when I miss a notification. Most of my energy is used to avoiding missing instead of tracking itself.*"
	Record	Less use burden during working hours	27	"*I don't like receiving too many notifications during my working hours. Thus, one reminder can reduce the using pressure of such app.*"
		Freedom and flexibility of tracking	36	"*I can use the Trapp app whenever I eat something and specify eating content at my convenience.*"
		Forget reporting if miss the notification	14	"*One notification in the morning did not help me a lot. I must remember to use Traqq by myself, which distract my attention from working.*"

4.2 Qualitative Analysis

4.2.1 Preferred Method in WfH Context. According to the follow-up interviews after each individual week, most participants showed a positive attitude toward using the app during their working hours at home. Twelve participants believed the 4-hour Recall and the Food Record brought them to be more aware of tracking their daily intakes, such as eating too many snacks or not enough fruit. Eleven participants tried to eat regularly after tracking food intake at home. Regarding the preference of the two methods (4-hour Recall and Food Record), total 138 quotes were selected (as shown in Table 5). The various opinions and reasons given by participants can be summarized as follows.

Food Record Twenty-one participants preferred the Food Record method for daily intake tracking in the WfH context. The reasons for their choice can be summarized as following aspects. First, one notification per day could well remind participants without extra disturbing. For example, 13 participants did not use or directly muted their mobile phones during their working hours at home. Thus, one notification could "*be successfully received in the morning* (P8, P22, P29, P31, P32)", "*reduce using pressure and keep using aspiration* (P2, P4, P16)", and "*do not disturb working schedules* (P2, P4, P11, P13, P14, P28, P31)". Second, the Food Record method provided participants more space and freedom to fill in the content of daily dietary intake. For instance, some participants mentioned that "*I can use the app whenever I eat something, which doesn't disturb*

Table 6: Interview findings of future design opportunities.

Keyword	Method	Theme	Frequency	Exemplar Quotations
Reminder	4-hour Recall	Integrated reminders into working routines	23	"*I have busy and various schedules every day. So, I hope the Traqq app could learn my schedules and send me the notifications at the exact time when I do eat.*"
	Record	Backward reminder	18	"*I always realized to track my intake when I check my to-do list before I go to bed. So, if I can receive the notification in the evening instead of morning, it would be more helpful.*"
Motivation	Both	Playful tracking approach	39	"*It would be better if the digital tool could be an intelligent friend. I can 'talk to it' about my intake rather than just fill in my data mechanically.*" "*I look forward to a digital game, where the process of tracking is to complete different level of tasks .*"
		Well-designed interface	17	"*Traqq shows good academy functions but lacks user-friendly interface. I hope Traqq can be designed with colorful icons and interesting interactions.*"
		Regular and personalized feedback	31	"*I do care about my daily calories intake and nutrition balance, so I look forward to a daily overview about my intake.*"
Tracking process	Both	Reduce repeated reporting	34	"*It would better if Traqq could remember my historic reporting. Since I always eat similar food content.*"
		Graphical reporting approach	19	"*If the food content could be visualized with graphical items, I will directly find the right categories and take less time to report my intake during my working hours.*"
		Connecting to shopping list	25	"*If Traqq knows the types and amount of foods I bought, it would be easier for me to insert accurate intake. *"

my working agenda. (P1, P5, P8, P29, P31)", "*I have more time to specify what I eat at my convenience.* (P11, P 19, P22, P31, P32)", "*I can not only use Traqq to track what I have already eaten, but also can let me make an eating plan for the rest of the day. So, I can be aware of my eating and balance my intake.* (P4, P32)". Additionally, the responses also indicated that these 21 participants did not choose the 4-hour Recall method was mainly due to the excessive reminder settings. P1 stated that "*I don't like 4-times notifications every day, because the notifications don't suit my working schedule well*". P23 mentioned that "*I feel stressed when I miss a notification. Most of my energy is used to avoiding missing instead of tracking itself*".

4-hour Recall In contrast, 9 participants selected the 4-hour Recall method as their preferred method. Those who preferred the 4-hour Recall method stated that the fixed 4-time notifications were easier to follow and matched their structured working routine well. For instance, some participants mentioned that "*I like the reminders. When I receive the notifications, they help me to remember to insert my intake into the Traqq app straightforward* (P9, P10)". Some other participants stated that "*My working routine is fixed. The setting of these four notifications is reasonable and can be integrated into my working routine perfectly* (P13)". Yet, these participants did not prefer the Food Record method because they would forget to use the Traqq app after switching off the notification. As P26 mentioned that "*One notification in the morning did not help me a lot. I must remember to use Traqq by myself, which distract my attention from working*". P30 stated that "*When I am busy, I always forget to fill in my intake into Traqq. And I realize my missing at very late of the day, which gives me too much psychological pressure*".

4.2.2 Design Opportunity of Future Digital Tool. Participants used the app for both weekdays and weekends during this field study. Twenty-seven participants mentioned that they preferred to use the app during weekdays at home rather than on weekends. Three participants had no preference. The reason for this choice was that most participants had structured working and eating behaviors on weekdays. It was easier to use for tracking their food intake due to regular routines. For instance, P1 stated that "*I don't check my phone during the weekend. Besides, I always have lunch at friends' home or go out, it is hard for me to recognize all ingredients in the dish and insert into the Traqq*". Moreover, total 206 quotes were selected (as shown in Table 6). 30 participants gave various suggestions about how to improve the app. According to the interview data, we identified three desired improvements as follows.

Reminder During the interviews, many participants expressed their concerns about missing the 4-hour Recall notifications, or they indicated that the notifications distracted their daily work and increased their psychological burden when they work from home. Regarding the Food Record method, some participants suggested that they hoped to gain a daily notification at the end of the day rather than in the morning. For example, some participants mentioned that "*When I get the notification in the morning, it reminds me a new day for tracking. But if I have heavy working schedules that day, I forget to use the app totally* (P1, P5, P16)", "*I always suddenly realized to use the app when I check my to-do list before I go to bed. So, if I can receive the notification at the end of the day, it would be helpful* (P4, P8, P19)". Regarding the 4-hour Recall method, participants expected the digital tool could send notifications according to their

working schedules and eating routines. For instance, some participants stated that "*I always have structured working routine and eating habits. Although, the time setting of notifications on Traqq is reasonable, it doesn't remind me at the time I want it to remind* (P22)", "*I normally don't eat breakfast, so the notification in the morning is meaningless to me* (P27)", "*I use a workout app, which can send me the notification on the time I normally have a break and do exercise. I hope the Traqq app could also send me the notification at the exact time when I do eat* (P9)".

Motivation Several participants indicated that tracking their food intake helped them to be aware of their intake during WfH period, because they have more food choices and easier access to food at home than in office. But passively being motivated to use the app brought them a lot of mental burdens and task loads. Therefore, they hoped digital tools could motivate them with interesting and playful approaches in Wfh context. On the one hand, participants suggested that digital tools could involve playful and gaming features, inspiring them to use the digital tool spontaneously. For instance, "*I do not like to check notifications on my phone, because too many apps send notifications. If the digital tool could attract my attention by speaking, I would be easier to notice* (P3)", "*I hope the digital tool could be a game, I can set daily or weekly goals and then get rewards. The process of tracking can be like passing a level in a game* (P4)", "*It would be better if the digital tool could be an intelligent friend. I can 'talk to it' about my intake rather than just fill in my data mechanically* (P22)". Some participants also expressed a well-designed and playful interface. They stated that "*colorful icons*", "*vivid interaction*", and "*more graphic elements*" could be better to improve their using intensions. On the other hand, regular feedback was expected by most participants. They mentioned that personalized feedback or an overview of their intake would strongly motivate them to use the digital tool for the long term. And the WfH context provides a good setting to display and overview their intake data without concerning about privacy compared to office context. For instance, "*I do care about my daily calories intake and nutrition balance, so I look forward to a daily overview about my intake* (P1)", "*I like to plan my weekly recipes in advance, I hope the digital tool could give me some shopping suggestions based on my intake last week* (P9)", "*I eat a lot of unhealthy snacks during my working hours at home. It could be useful if the digital tool could find alternatives with healthy ingredients* (P7, P29)", "*I always eat similar food during my working hours at home. I want the tool to give me more suggestions on how to extend my recipes* (P24)".

Tracking process From the follow-up interview, we learned that almost all participants desired a simplified tracking process during their working hours at home. First, 17 participants mentioned that they had similar foods for breakfast and lunch on weekdays at home. Thus, they expected that already-inserted foods could be remembered and grouped by the application, and then they could directly select from the history box. For instance, P21 stated that "*I always eat similar food on weekdays. By remembering my insert, I don't need to fill in manually again*". Second, 10 participants hoped to build a connection between Traqq and their shopping content. As they explained that "*If the digital tool already knows what the ingredients I plan to buy, then my tracking task is only to fill in the amount I eat for each meal".* Third, seven participants looked forward to involving more graphical elements in the digital tool instead of text only. The graphical elements were identified as a beneficial approach to make the searching and inserting process easier and more efficient. For example, P22 stated that "*Reading the food name in the text takes me too much time. I hope the app could add food pictures into the database. This can shorten the searching and inserting time when I use the app".*

5 DISCUSSION

This paper aimed to identify whether the food record or the 4-hour recall method would be better suited for office workers to track their dietary behaviors. Overall, the participants in this study had a positive attitude about using a digital tool to track their daily intake in the WfH context. The data collected from NASA-TLX and UTAUT2 questionnaires revealed, however, that most participants preferred to use the Food Record method during working hours at home. This result was also partly supported by the qualitative responses during the follow-up interviews, in which 21 participants stated that the Food Record method was their favorite method because 1) one notification per day could well remind participants without extra disturbing and 2) it provided participants more space and freedom to fill in the content of daily dietary intake. Both quantitative and qualitative results rejected our two hypotheses that the 4-hour Recall method could be better and more helpful in a WfH context. Moreover, according to the results discussed above, the qualitative results from the follow-up interviews also helped to yield some insights about design opportunities of future digital tools in a WfH context. We summarize them as two design implications, namely *Integrating reminder into WfH routines* as well as *Simple and playful using process*, as follows.

5.1 Integrating Reminder into WfH Routines

In daily work routines, participants usually have a fixed working period integrated with a structured eating pattern. During the working hours at home, however, we found that most participants focused on working schedules without checking notifications on smartphones regularly. Our study suggested that being disturbed by notifications could bring extra mental workload to many participants. This finding is in line with some previous studies that people found it difficult to return to a previous task after having been interrupted by smartphone notifications [20], and higher mental workloads were required when people receive notifications while focusing on their work [2, 35]. Therefore, in the WfH setting, the reminders for dietary assessments should not be disabled but rather designed with flexibility, according to users' working and eating routines. As suggested by Fogg [26], being associated with existing routines could make a task facilitated by digital tools easier to be accepted.

Besides, the notifications are beneficial for increasing usability of mobile health applications, user retention, and ease of achieving goals of dietary behavioral change [80]. According to our participants' suggestions, notifications on digital tools should be designed based on their WfH context, involve tailored forms (e.g., text, voice, ambient light) to specific individual, and allow user for customization. This is in line with some prior research studies. For instance, Muench et al. [56] pointed out that digital triggers should aim to provide the right type of notification, at right time, by adapting to

individual's specific contextual state. As suggested by Lee et al. [46], voice-based applications can help users focus on their current working tasks without extra effort with hands or eyes. Easy Nutrition [5] is a customized dietary app, which highlights the food nutritional information and value in a clear way to the users. However, prior works have found that few mobile digital tools are developed for working context, so, by extension, it also lacks attention on research on usage of dietary digital tools for WfH context.

5.2 Simple and Playful Using Process

Traqq is a self-reported application, which took participants some time to report their intake. The tracking approach for both the 4-hour Recall method and the Food Record method is inserting textual information manually. As mentioned by previous study [12], the disadvantage of such self-assessment methods is that it has reactivity bias and is intrusive for users. Therefore, digital tools should be designed with simplicity to promote easy and intuitive workflow for self-reporting, in order to support low levels of mental effort and a short time to use. According to interview results, many participants expected the digital form could autofill their historical data of intake, then they would not spend extra time to fill in the same ingredients as before. Although, Traqq does contain a 'My Dishes' function that has been developed for this purpose specifically. Users can insert all the items of their own dish and the amount consumed (e.g., a daily breakfast). The next time, the user can simply search for their dish and the individual items are reported automatically [50]. This function simplifies reporting even more than the suggested autofill function, as the entire dish can be reported at once instead of per item. Besides, integrating shopping plans into the digital tool was also suggested by some participants. These participants preferred to make their eating plans on a weekly basis. However, connecting digital tools to supermarket services would bring fort privacy concerns. Therefore, the future design should be incorporated with the grocery shopping assistant feature with special attention to privacy protection. Then, the only thing users need to do is to insert the amount of intake per day. Simplifying using process of health-tracking technologies was also suggested by some other studies. For instance, Fogg [26] mentioned that a health behavior change task needs to be simple and provide positive reinforcement to motivated people to turn it into a habit.

Moreover, many participants also suggested adding some game elements to encourage them to repeatedly use the tracking tools in a longer term in WfH context. Some participants suggested adding some conversational user-system interactions, such as "*insert intake by speaking*", and "*being advised by the system to eat healthy food*", because the convenience and data privacy in WfH context could be guaranteed. According to previous research, voice is the fundamental means of human communication [46]. Voice-based applications can provide every user with a friendly interface by adding a feeling of natural interaction [30]. For instance, a Home Radio concept was presented by Eggen et al. [23] that using sound and light could create pleasant connections among family members with sharing daily experiences such as eating, working, watching television, etc. WeightMentor application [34] could provide timely, automated, and personalized feedback, react quickly to users' needs, and make it easier for users to find and search the information via voice. Moreover, there have some other playful designs for healthy eating in the Human-Food Interaction field. For example, Arnold et al. [7] explored a cooperative VR game to promote peer-supported eating behaviors. Because of the increasing intake of snacks during WfH period, Park et al. [67] proposed a mobile game called Snackbreaker that aim at letting users exposed to the impact of healthy snack choices in unintrusive approach. TasteScreen [53] is also a interface technology that allows user to lick liquid residue of various flavors that drips onto the screen. Moreover, some forms of playful interactions, such as daily game challenges and virtual rewards, were also expected by some participants. With these persuasive game designs, the digital tools for healthy eating in WfH context are expected to help individuals engage in the process of health promotion [9, 18, 63].

5.3 Limitation

The findings of this paper may need to be cautiously interpreted due to the following limitations. Firstly, the study was conducted with a small sample size with an imbalanced sex ratio, which might not be adequate to quantitatively prove the 4-hour Recall method and the Food Record method in the WfH context. Secondly, the findings were not representative of expected digital tool features globally. Different regions may have very varied working cultures and food cultures [37], it is valuable to evaluate digital tools in one particular cultural context.

6 CONCLUSION

Due to COVID-19, workplaces have rapidly shifted from the office into the home. It is necessary to understand workers' eating patterns in this transitional period and identify design opportunities for health-promoting technologies that can support their nutritional health in the WfH context. Based on the societal context of the Netherlands, we set out this study to compare the user acceptance of two dietary tracking methods (4-hour Recall vs. Food Record) and their feasibility to be adopted for the WfH context, as well as to identify design opportunities to appropriate digital tools into the weekday eating routines. The comparisons between the two methods showed participants' positive attitudes toward using dietary assessment methods in the WfH context. Regarding quantitative results, we tested the workload and acceptance of these two methods with NASA-TLX and UTAUT2 questionnaires. Regarding qualitative results, the main reasons for participants' preference were more flexible filling time and lower mental burden with the Food Record method. Additionally, based on responses in the follow-up interviews, we presented a set of design implications for future digital tools to promote healthy eating during working hours, including integrating reminders into daily working and eating routines, simplifying the tracking process, and adding gaming elements into digital tools. The results of this study will be used to design effective dietary assessment and intervention tools. Eventually, we plan to conduct a longitudinal field study based on a digital tool to examine our design's effectiveness for easily tracking daily intake during working hours in WfH context. Additionally, future work could also focus on evaluating dietary assessment in WfH context, implementing the design implications reported here into a

new healthy eating application, and investigating its potential in stimulating eating behavior change for WfH.

ACKNOWLEDGMENTS

We thank questionnaire respondents and interview participants for their help in the study. The first author of this paper is supported by China Scholarship Council. The corresponding author is supported by The National Social Science Fund of China (21CG192) and Beijing Institute of Technology Research Fund Program for Young Scholars (XSQD202018002). This research is also funded by the 4 Dutch Technical Universities, 4TU—Pride and Prejudice program (4TU-UIT-346).

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