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## Iterative Development of an Innovative Smartphone-based Dietary Assessment Tool, Traqq

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**TITLE:**

Iterative Development of an Innovative Smartphone-based Dietary Assessment Tool, Traqq

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Technology-based dietary intake assessment; Smartphone applications; Development and evaluation; Recall; Food record; Adults

**SUMMARY:**

This article describes the protocol for the development of an innovative smartphone-based dietary assessment application **Traqq**, including expert evaluations and usability testing.

**ABSTRACT:**

To collect dietary intake data in a fast and reliable manner, a flexible and innovative smartphone application (app) called **Traqq** was developed (iOS/Android). This app can be used as a food record and general 24-h recall (or recall shorter periods). Different sampling schemes can be created on either prespecified or random days/times within a predetermined period for both methods, and push notifications to urge the participants to register their food intake. In case of non-response, notifications are automatically rescheduled to ensure complete data collection. For use as a food record, respondents can access the app and log their food intake throughout the day. Food records close automatically at the end of the day; recalls close after submission of the consumed items. The recall as well as the food record module provide access to an extensive food list based on the Dutch food composition database (FCDB), which can be accustomed to fit different research purposes. When selecting a food item, respondents are simultaneously prompted to insert portion size, *i.e.*, in household measures (*e.g.*, cups, spoons, glasses), standard portion sizes (*e.g.*, small, medium, large), or weight in grams, and eating occasion/time of consumption. Portion size options can be adjusted, *e.g.*, only entry in grams in case of a weighed food record or time of consumption instead of eating occasion). The app also includes a **My Dishes** function, which allows the respondent to create their own recipes or product

combinations (*e.g.*, a daily breakfast) and only report the total quantity consumed. Subsequently, the app accounts for yield and retention factors. The data are stored on a secure server. If desired, additional questions—general or those related to specific food items or eating occasions—can be incorporated. This paper describes the development of the system (app and backend), including expert evaluations and usability testing.

## INTRODUCTION:

Accurate dietary assessment is crucial to ensure the quality of studies on the role of nutrition in health and disease prevention. Currently, such studies generally use established self-report dietary assessment methods, *i.e.*, food frequency questionnaires, 24-h recalls (24hRs), and/or food records<sup>1</sup>. Despite the fact that these methods are of major importance for nutrition research, they also possess various drawbacks, *e.g.*, memory-related bias, social desirability bias, and are burdensome for the respondent as well as the researcher<sup>1,2</sup>. Recent technological inventions now offer the opportunity to overcome these drawbacks. During the past years, various research groups seized this opportunity and developed web-based and smartphone-based dietary assessment tools for nutrition research that address some of these known drawbacks (see Eldridge et al.<sup>3</sup> for an extensive overview of web- and smartphone-based tools), *i.e.*, reduce causes of error, improve user-friendliness, and decrease the participant's and researcher's burden<sup>1</sup>.

Nevertheless, the number of fully automated and validated smartphone applications (apps) that are appropriate for nutrition research is still limited. Most of the available dietary assessment apps (*i.e.*, commercially or developed for research) are either not fully automated (*i.e.*, require manual coding of food items) or are not (well) validated<sup>3</sup>. Moreover, most available validated apps have been developed for one specific research purpose and use in a specific country; due to rather fixed designs, re-using such apps for other research purposes or in other countries seems challenging<sup>3-8</sup>. Finally, despite the availability of food record-based apps, to date, there are no recall-based apps. Although food records are prone to reactivity bias, *i.e.*, respondents may alter their food intake due to the awareness that they are being observed<sup>2,9</sup>, this is not the case for recalls, which emphasizes the need for the development of a validated recall-based app<sup>10</sup>. An innovative dietary assessment app called **Traqq** was developed for use in the Netherlands which can be used as a food record as well as a recall, depending on the research question<sup>1</sup>.

Besides the possibility to alternate between the food record option and recall option, this app also differs from other dietary assessment tools because of its flexible nature. Specifically, regarding the food list, portion size estimates, sampling schemes, and the possibility to incorporate additional questions. The level of flexibility in the system enables tailoring to multiple research purposes that require accurate assessment of dietary behaviors. Currently, the app is in the process of being validated and will be ready to be used in various types of nutrition related research. The app can also be used, and perhaps further improved for use, in nutritional intervention programs to measure and influence dietary behaviors. As the development of reliable dietary assessment tools is challenging, and reports on these processes are scarce, especially with respect to user and expert involvement<sup>3,11,12</sup>, this paper provides a detailed

overview on how different information sources were integrated in the systematic and iterative development of this smartphone-based dietary assessment app. The process incorporates theory, expert consultation, and user engagement.

## **PROTOCOL:**

NOTE: All the procedures including human participants were conducted in a non-invasive manner by means of mostly qualitative research methods. Informed consent was obtained from all participants before the start of the evaluations. This protocol describes the iterative developmental process that can be roughly divided into four stages in which stages 1–3 are intertwined (**Figure 1**).

[Place **Figure 1** here]

### **1. Conduct extensive formative research in preparation of the actual developmental process.**

1.1. Perform desktop research exploring existing web- and smartphone-based dietary assessment tools, with special attention to features known to be of key importance for accurate food intake data collection, *i.e.*, method of food entry (including the food list and underlying FCDB) and portion size estimations.

1.2. Inspect existing web- and smartphone-based dietary assessment tools focusing on aspects such as dietary assessment methodology, information provision, reliability, search engine, and implemented features (*e.g.*, images, barcode scanner, recipe functions).

1.3. Consult experts in the field of dietary assessment.

NOTE: Results of the desktop research and inspection of existing tools were discussed with experts in the field of dietary assessment, leading to a draft design plan for the development of the app. This draft design plan was evaluated by the experts and further improved as required.

### **2. Design the dietary assessment app**

2.1. Create the visual design of the app considering important aspects such as animation, branding, color, layout, and typography<sup>20</sup>.

NOTE: As space, color, fonts, graphics, and interface elements highlight content and convey interactivity, it is essential to incorporate elements facilitating the functionality of the app.

2.2. Select a trustworthy FCDB (here, NEVO) to facilitate nutrient calculations of the collected food intake data.

2.3. Create a food list by critically evaluating the description of the food items mentioned in

the FCDB.

NOTE: FCDBs are mostly developed for professional use; food descriptions are often complex and hinder searchability (*e.g.*, “margarine low-fat 35% fat < 10 g of saturated fats unsalted”<sup>23</sup>).

2.4. Formulate search engine requirements; consider the use of punctuation marks, foreign names, misspellings, different search terms, and ranking of search results to facilitate searchability of food items.

2.5. Select portion size estimation (aid) by evaluating various existing dietary assessment tools and field testing of suitable options.

2.6. Design routing within the app to ensure that the user’s navigation through the app is logical, predictable, and easy to follow.

2.7. Design backend features and requirements to control the app; include functions related to overall project management, project-specific management (*e.g.*, participants, invitations, data collection), and user management (*e.g.*, authorizations).

### **3. Evaluations by researchers**

NOTE: Following each upgrade, the app was tested by nutrition scientists and research dieticians with expertise in dietary assessment (in-house testing) to verify whether functionalities improved as anticipated. The following instructions are to be executed by researchers.

3.1. Conduct expert evaluation by means of cognitive walkthroughs to simulate a first-time user experience so that the experts can explore the app individually and without guidance<sup>28</sup>. Ensure that the cognitive walkthroughs consist of the following steps.

3.1.1. Make sure that the expert completes a general questionnaire inquiring about the brand and type of smartphone.

3.1.2. Install the app on the expert’s smartphone.

NOTE: To ensure proper installation and functioning and minimize the risk of interruptions during the evaluation, it is recommended that the researcher first verifies the app’s functionality.

3.1.3. Instruct the expert on test procedures in which each expert is asked to take on the role of first-time user (*i.e.*, research participant). Emphasize that the evaluation is performed from a user’s perspective and not from the expert’s own perspective.

NOTE: The user was assumed to be an experienced smartphone user and to have knowledge on the use of apps in general. However, this app was used for the first time.

3.1.4. Start the screen and audio recording.

3.1.5. Have the expert complete the cognitive walkthrough while using the app and carrying out a predetermined set of tasks<sup>31</sup>: 1) “I want to record my dinner. I started with a cup of tomato soup and a glass of milk.”, 2) “Thereafter, I ate a pasta dish, which I consume regularly and want to enter it as a favorite (*i.e.*, predecessor of **My Dishes**).” [recipe was provided], 3) “As I also consumed the pasta dish, I want to add this to today’s food intake record.”, and 4) “I entered everything I ate during dinner. I want to check my entry once more and then submit it.”.

NOTE: While performing the tasks, the expert informs the researcher about his/her thought process, *i.e.*, by explaining the steps needed to be completed to fulfill the described task.

3.1.6. Conduct a brief follow-up to clarify ambiguities<sup>32</sup>, and provide the expert the opportunity for additional feedback.

3.1.7. Evaluate the results of each expert by checking the recordings to ensure that tasks were executed as intended and by reviewing the additional comments provided.

3.1.8. Share the results with the experts to assess whether assumptions made based on the recordings were correct.

NOTE: Results of the evaluation were discussed and prioritized in consultation with the experts. Based on the results of this evaluation, the app was further upgraded.

3.2. Conduct usability testing with intended users to evaluate the app’s usability and likability among the intended users by means of think-aloud interviews and the system usability scale (SUS)<sup>33</sup> by following these steps:

3.2.1. Recruit participants who are representative of the target user population<sup>35</sup>.

3.2.2. Instruct the participant regarding the study procedures, including the recording of screen and audio. Then, obtain informed consent from the participants.

NOTE: It is important that the researcher encourage the participant to “think-aloud” during the evaluation, *i.e.*, explaining their thoughts on the required steps to complete each task whilst performing the task, as well as commenting on what functionalities did or did not work well.

3.2.3. Install the app on the participant’s smartphone.

NOTE: To ensure proper installation and functioning and minimize the risk on interruptions during the evaluation, it is recommended that the researcher first verify the app’s functionality.

3.2.4. Ask the participant to perform a practice task for the think-aloud interview: ask participants to visualize their bedroom and count the number of windows, while telling the

researcher about what they saw and thought while counting the windows. Next, ask the participants to approach one of the windows in their bedroom and describe their experiences on their way to that window.

NOTE: A practice task was provided and repeated if needed to ensure that participants felt comfortable to think-aloud as desired<sup>37</sup>.

3.2.5. Start the screen and audio recording.

3.2.6. Ask the participant to complete actual think-aloud interview with the predefined tasks: the participant must: 1) record everything they ate and drank during the previous day, and 2) record a regularly consumed dish through the **My Dishes** function.

3.2.7. During the session, observe, take notes, and stimulate the participants to keep thinking aloud, if needed, by simple prompts such as “Keep talking out loud”, “Tell me what you think”, or “Tell me what is on your mind”. Minimize further interactions to prevent interference with the participant’s thought process<sup>28,32</sup>.

3.2.8. Conduct a brief follow-up to clarify ambiguities<sup>32</sup>.

3.2.9. Ask the participant to complete an evaluation questionnaire with general questions related to age, sex, educational level, type of smartphone, level of smartphone experience (*i.e.*, experienced users are more likely to perform tasks quick and correctly<sup>38</sup>), as well as the SUS<sup>33</sup>—a 10-item questionnaire to assess the system’s usability by means of Likert scale scoring ranging from 1 (strongly disagree) to 5 (strongly agree).

3.2.10. Analyze the data from each session by 1) transcribing, coding, and creating (sub)themes, and 2) calculating the SUS score using a predefined formula resulting in a score between 0 to 100<sup>33</sup>, where a score of >68/100 indicates that the tool functions at above-average level of usability and a score >80/100 indicates excellent usability<sup>39,40</sup>.

NOTE: It is recommended that the researcher who guided the session analyze the data by using qualitative data analysis software. A second researcher can be consulted in case of ambiguities.

3.3. Conduct quantitative validation of dietary intake records against validated traditional methods and preferably independent measures<sup>3</sup>.

NOTE: The app is being validated against web-based and telephone-based (*i.e.*, interviews) 24hRs as well as independent urinary and blood biochemical markers. As the quantitative validation of the app is outside the scope of this paper, this will not be discussed further.

#### 4. Using the backend system for app and study management

NOTE: The system has three authorization levels: (1) administrator—this authorization level

provides access to all sections of the backend (*i.e.*, creating new users, determining user authorization, and granting users access to one or more projects); (2) project managers—this authorization level allows access to specific projects and the possibility to create new projects; and (3) researchers—this authorization level only provides access to the specific projects that researchers are involved in.

#### 4.1. Management of users and projects in the backend by administrators

4.1.1. Access the online backend via **traqq.idbit.net**, with login credentials (*i.e.*, username, password).

4.1.2. Create a new project by clicking on the **Projects** tab and then on **Create a new project**.

4.1.3. In the next screen, enter the requested project details (*i.e.*, project name, contact description, contact email, contact phone, contact website).

NOTE: Only the project name is mandatory to create a new project. The contact description, email, phone number, and website will become visible in the app under the **Contact & Info** button.

4.1.4. Select the desired features (*i.e.*, product list, ask eating occasion and/or time of consumption, record or recall).

NOTE: Each new project requires individual decision-making with respect to the most appropriate dietary assessment method (*i.e.*, record or recall), food list, portion size estimation, and eating occasion or meal times.

4.1.5. Save the new project by clicking on **Save**.

NOTE: When the screen closes, the administrator returns to the **Project overview** screen.

4.1.6. Next, create a new user by clicking on the **User** tab and then on **Add new user**.

4.1.7. In the following screen, enter a **Username**, a **Password**, and assign the user a **Role** (*i.e.*, administrator, manager, or user).

4.1.8. Save the new user by clicking on **Save**.

NOTE: When the screen closes, the administrator returns to the **User overview** screen.

4.1.9. Assign a user to a project by clicking on the notepad icon (*i.e.*, **Edit** column) for a specific user.

4.1.10. Assign a project by opening the dropdown menu under **Linked Projects**, selecting the



desired project, and clicking on **Add**.

NOTE: This action needs be repeated for each project the user needs to be assigned to.

4.1.11. Communicate the log-in credentials to the new user along with the backend URL.

#### 4.2. Management of projects in the backend by researchers (*i.e.*, Manager or User role)

4.2.1. Log in to the backend via **traqq.idbit.net** by using the credentials provided by the administrator.

4.2.2. Click on **Go to projects** to manage the projects.

4.2.3. Click on the arrow in the **View** column for the desired project.

NOTE: After doing this, the researcher is taken to a **Project Overview** page, and new tabs for this specific project appear.

4.2.4. Enter the participants in the backend by clicking on the **Participants** tab. Next, when a **Participant Overview** screen appears, click on **Add new participant**.

4.2.5. In the following screen, enter **Codename**, **Notes** (optional), **Login ID**, **Login Key**, and ending with **Save**.

NOTE: It is recommended that the Participant's study ID be used as both codename and login ID. This minimizes confusion for the participant in case of multiple login credentials. Moreover, the codename is visible in the responses. Using the participant ID makes it easy to use the data. This option needs to be repeated for each participant. For larger groups, **Import participants from file** (.csv) can be used. Here, the same details are required for each participant. The backend may not contain any personal information of participants.

4.2.6. Schedule invitations for each participant by clicking on the **Invitations** tab. Next, when an **Invitation Overview** screen appears, click on **Add new invitation**.

4.2.7. In the following screen, select a **Participant** from the dropdown menu, and enter **Period start time**, **Period end time**, **Opening time**, **Closing time**, **Survey URL** (*i.e.*, optional for implementation of additional questions), **Notes** (optional), **Enable** (always yes).

NOTE: The **Period start** and **end time** refer to reporting time frame (*i.e.*, what has been consumed between ... and ...). In contrast, opening and closing time refer to the period in which the participant can actually report their intake. The correct implementation of an external survey requires some coding; for this, help from the administrator is recommended. For the majority of the invitations, the **Import invitations from** (.csv) option under **File** can be used. The file requires the same information as for the manual input. Invitations can also be created via **Sampling**

**Schemes** (*i.e.*, where the system generates a random invitation scheme across different days and times based on a preset of rules such as sampling period, number of required invitations, response deadline). An advantage of the **Sampling Schemes** option is that the system automatically schedules a new invitation in case of non-response.

4.2.8. Track data collection via the **Calendar** tab by selecting a participant of interest from the dropdown menu.

NOTE: The calendar provides an overview of scheduled invitations within a project, either in general or for specific participants. Future invitations are portrayed in blue, completed past invitations are green, while past invitations without response are red. Responses to invitations can also be checked via the **Response** tab.

4.2.9. Track responses via the **Response** tab.

NOTE: In the **Response** section, the reported food intake data (*i.e.*, food item, consumed amount, eating occasion and/or time of consumption) is gathered.

4.2.10. Requests the administrator for data export.

NOTE: Data can be exported from the backend to a .csv file for further analysis (*e.g.*, responses/food intake data, compliance data) by the administrator. Responses include reported food items, selected portion sizes, consumed amounts in grams, and eating occasions/times.

4.2.11. Import the .csv file into nutrition calculation software for in-depth nutrient analyses.

NOTE: The data can be imported into nutrition calculation software that makes use of the Dutch FCDB.

## 5. Use of the app by the participants during the study

5.1. Download the freely available app from the App Store (iOS) or Google Play Store (Android), and access the app by logging in.

NOTE: Login credentials, as provided by the researcher, are required to access the app (step 4.2.5.). After logging in, the app sends invitations as scheduled in the backend based on the participant's credentials (step 4.2.7.).

5.2. After receiving an invitation via the app, report food intake.

NOTE: Participants can only register their food intake on predetermined days and times.

5.2.1. Open the app by clicking on the notification received or by opening the app via the app icon.

NOTE: After opening the app, an **Invitation Overview** screen appears where previous and current invitations are displayed.

#### 5.2.2. Click on the open invitation.

NOTE: Participant is taken to an **Overview** screen where the invitation period is visible.

#### 5.2.3. Enter the food item consumed first by clicking on **Product toevoegen** (Add food item).

NOTE: The participant is taken to the **Search** screen.

5.2.4. Start typing the name of the consumed item (*e.g.*, orange juice [jus d 'orange]). Click on the desired item as it appears whilst typing.

5.2.5. In the following screen, report the consumed amount (**Hoeveelheid**), corresponding portion size description (**Portie**), eating occasion (**Maaltijdmoment**) and/or time of consumption (**Tijdstip**), and end by saving (**Opslaan**).

5.2.6. Repeat the aforementioned steps until all food items are reported.

5.2.7. Submit the list (recall) by clicking on (**Lijst versturen**) (Send List), or the invitation automatically closes at the end of the day (record).

NOTE: The **Send List** option is also visible in the record version, so participants using the record can also send their input to the database. However, even if the data is already sent, the invite still closes at the end of the day, sending all data to the server.

### REPRESENTATIVE RESULTS:

The system (app and backend) was developed using the steps outlined in the above described protocol; the key results of this process are described below, concluding with the final design of the app.

#### Formative research

In addition to extensive literature review, several web-based tools were inspected (*e.g.*, Compleat<sup>13</sup>, ASA24<sup>14</sup>, Foodbook24<sup>15</sup>, MyFood24<sup>16</sup>) with respect to dietary assessment methodology and implemented features. In addition, the performance of several food tracking apps frequently used in the Netherlands were compared (*e.g.*, MijnEetmeter<sup>17</sup>, MyFitnessPal<sup>18</sup>, Virtuagym Food<sup>19</sup>), focusing on aspects such as dietary assessment methodology, provision of information, reliability, search engine, and the use of additional features (*e.g.*, images, barcode scanner, recipe functions). The results of this inspection led to the decision to develop the app in such a way that it can be used as a food record and a recall. Moreover, it led to the implementation of the **My Dishes** function, which can be used to create original recipes or frequently consumed product combinations (*e.g.*, a daily breakfast). Within this function, yield and retention factors are

441 automatically taken into account.

442  
443 To accurately quantify food and nutrient intake, a complete, albeit practical, food list is crucial.  
444 Compiling such a food list requires a trade-off between the extensiveness of the food list and the  
445 searchability of the food items (*i.e.*, food descriptions need to be clear, understandable, and easy  
446 to locate)<sup>41,42</sup>. As food composition data form the fundamental basis for dietary assessment<sup>21,22</sup>,  
447 it is important to ensure that the developed food list can be linked to accurate food composition  
448 data. The food list included in the app is based on the Dutch FCDB (NEVO)<sup>23</sup>, which was selected  
449 for its reliability and rich food composition data. Originally, the NEVO consists of 2,389 food items  
450 (version 2016/5.0), which was reduced to a food list of 1,449 items by eliminating “confusing  
451 items” (*e.g.*, foods that cannot be consumed raw, foods that cannot be consumed without  
452 additions) or items that are not as essential to include (*e.g.*, due to low consumption rates based  
453 on the Dutch Food Consumption Survey (DNFCS)<sup>43</sup>).

454  
455 Additionally, the NEVO contains similar foods with different brand names; in such a case, only  
456 the generic option was included in the food list. To further facilitate usability, some food items  
457 were renamed to eliminate needless terminology such as ‘prepared’, ‘frozen’, ‘average’, and  
458 ‘natural’. This “cleaning protocol” was developed by three well-trained research dietitians and  
459 executed by means of a syntax, which can be rerun once NEVO is updated. In addition, to  
460 optimize the searchability of food items, 1,019 well-known synonyms of the included foods were  
461 added to the food list. Thus, the food list included in the app eventually comprised 2,468 items.  
462 An overview of the food list development is displayed in **Figure 2**. To note, although this extensive  
463 food list has been developed for general use, the backend of the app does allow the import of  
464 alternative food lists if required.

465  
466 [Place **Figure 2** here]

467  
468 Another crucial aspect of dietary assessment is the quantification of portion sizes. Although  
469 portion size estimation aids (PSEAs), *e.g.*, images, referent objects, and standard portion sizes,  
470 support the reporting of the amounts of foods consumed<sup>24,26,44</sup>, misreport of portion sizes is still  
471 a substantial source of bias<sup>24,25,45,46</sup>, and literature on the effectiveness of the different PSEAs is  
472 inconsistent<sup>26</sup>. Food images, portion size suggestions (*i.e.*, standard sizes and household  
473 measures), and free entry of weight in grams are the most used PSEAs in web- and smartphone-  
474 based dietary assessment tools<sup>34</sup>. For example, whereas portion size suggestions (*e.g.*, cups,  
475 spoons, small, large) are used in tools such as Compl-eat<sup>13</sup> and Oxford WebQ<sup>47</sup>, images aid  
476 portion size estimates in tools such as ASA24<sup>14</sup> and Myfood24<sup>16</sup>. To investigate the most  
477 appropriate PSEA for the app, a pilot study was conducted to compare the accuracy of portion  
478 size suggestions (*e.g.*, small, medium, large, or cup, spoon), free entry in grams, and portion size  
479 images. The results of this study led to the implementation of portion size suggestions as the  
480 PSEA in the app along with the option to enter amounts in grams<sup>27</sup>.

## 481 482 **Expert review**

483 The aim of the expert evaluations was to qualitatively evaluate the app in terms of functionality  
484 and ease of learning. As many users prefer to learn software by exploration<sup>29</sup>, a system’s level of

learnability is important. A total of 10 experts, *i.e.*, 4 (research) dietitians and 6 nutrition and health behavior experts (scientists) participated in the cognitive walkthroughs in which 60% used an Android smartphone. Most importantly, expert evaluations indicated that the first version of the app was not sufficiently intuitive, *e.g.*, menu-structure was judged unclear due to vague buttons/icons, and the search engine generated an illogical order of results. Another critical point arising from the expert reviews related to the fact that selected items could not be modified. Based on these results, the design of the app was considerably upgraded from stage 2 onwards (**Figure 1**).

### Usability evaluation

A total of 22 participants participated in the think-aloud interviews, which formed the basis of the usability evaluation. The initial sample size was set at 20 participants<sup>36</sup>, after which data saturation was assessed. As data saturation was not reached after 20 interviews, inclusion continued while assessing data saturation after each successive interview. Participants had a mean  $\pm$  standard deviation age of  $48 \pm 17$  years (range 22–70 years); 36% were male, and the majority of the population was highly educated (55%). In addition, most participants used an Android device ( $n=14$ , 64%), and almost all participants had over 1 year of experience with smartphone use ( $n=21$ , 96%) (**Table 1**). All participants completed the tasks without or with minimal instruction.

[Place **Table 1** here]

Whereas some participants ( $n=13$ , 59%) indicated difficulties while using the **My Dishes** functionality; others ( $n=5$ , 23%) encountered minor functionality issues such as slow response of the menu button and difficulties using buttons related to insufficient screen size of smaller smartphones). Moreover, 15 (68%) participants indicated their preference for an option to enter consumed portion sizes in grams. Finally, evaluation of the SUS score indicated a rating of 79/100 (range 40–100), wherein only 3 out of the 22 participants rated the app below 68/100 and 13 rated  $>80/100$ , which suggests that the app can be considered user-friendly. Thus, overall, the suggested improvements were minor, and usability evaluations were promising. Subsequently, suggestions for improvement were discussed within the research team and, if deemed relevant, incorporated in the stage 4 upgrade to further optimize likability and usability of the app (**Figure 1**).

### Final design

The steps described in the protocol and the results of the evaluation study eventually resulted in a final design for the app and the backend, which aimed for a simple visual design. This app can be used as a food record and a recall. As described previously, the food list is a modified version of the NEVO. Portion size estimation is supported by food-specific portion size suggestions; consumed portions can also be entered in grams. In case of the recall version of the app, the researcher has the possibility to select different timeslots (*e.g.*, 2hR, 8hR, or 24hR). To collect food intake data on different days and times, various sampling schemes can be created within a predetermined period. Push notifications invite respondents to record their food intake. To ensure complete data collection, invitations are automatically rescheduled in case of non-

response. Within the recall module, respondents can only report their food intake after receiving an invitation. In case of the food record, respondents can access the app and log their food intake throughout the day.

In contrast to most 24hR tools, the recall module of the app is not based on the Automated Multiple-Pass Method—a five-step method for collecting food intake data for the previous 24 h<sup>48</sup>—as this method is too elaborate and time-consuming for use in an app. More specifically, to increase usability and enhance the compliance of the food intake recordings<sup>11,38,49</sup>, navigation was reduced to a minimum by limiting the number of screens that need to be accessed to 4 (**Figure 3**): 1) an **Overview** screen showing the reporting window; 2) consumed food items are reported through the **Search** screen, and once the desired item is selected 3) a dialog box appears probing eating occasion and consumed amount, after which 4) the user returns to the **Overview** screen now showing the recorded food items. In addition, the user could also use the **My Dishes** function to create recipes or product combinations, which can be entered via the **Menu** button.

[Place **Figure 3** here]

The data are stored on a secure server. If desired, additional questions—general or related to specific eating occasions or food items—can be incorporated. The app can connect with online survey tools. Therefore, it is possible to conduct a survey unrelated to food intake via the app at prespecified times (*e.g.*, context, behavioral, mood questions). It is also possible to ask specific questions related to reported food items or eating occasions (*e.g.*, when apples are reported, when lunch is reported). The use of online survey tools provides an opportunity to ask many different questions via the app. The collected food intake data can be exported from the server and imported into nutrition calculation software for further analyses. In case of the use of additional questions, these data will be available in the survey tool as usual. The aim was to develop a well-structured and easy-to-use app. Some screenshots of the design can be seen in **Figure 4A–E**.

[Place **Figure 4A–E** here]

## FIGURE AND TABLE LEGENDS:

**Figure 1: Overview of the stages of the iterative development process of the app.** The development process consisted of five stages in total. However, the process was iterative which means that stages 1 through 3 were intertwined.

**Figure 2: Structure of the food list developed for the app.** The food list is based on the Dutch food composition database (FCDB) and corresponding portion size suggestions and synonyms were added for each item in the final food list.

**Figure 3: Schematic overview of the routing in the app.**

**Figure 4: Screenshots of the final version of the app. (A) The Start/Overview screen, showing**

the invitation with the (in this case) 2 h-recall period. The user can press **Product toevoegen** (*i.e.*, Add item) to report a food item or **Niets gegeten of gedronken** (*i.e.*, I did not eat or drink anything) in case nothing was consumed during this time window. (B) The **Search** screen, showing results matching the search term “Jus” from the food list. The desired item can be selected from the search results. (C) A pop-up screen requires input of details on the selected item “Jus d’orange”. In this case, the app asks for the amount consumed and eating occasion. The user can go back to the search result by pressing **Annuleren** (*i.e.*, cancel) or **Opslaan** (*i.e.*, save) to go further. (D) The **Overview** again, this time showing all the reported items. Another item can be added (**Product toevoegen**) or the input can be sent (**Lijst versturen**). (E) After selecting **Lijst versturen**, a pop-up appears asking the user if they are sure that they want to send, and reminds the user that it is not possible to make any more changes after the list has been sent. The user has the option to cancel (**Annuleren**) or send (**Versturen**).

**Table 1. Characteristics of the study population and results of usability evaluation.** Only the results of the system usability scale (SUS) are portrayed in this table along with the participant characteristics.

## DISCUSSION:

This paper presents the iterative developmental process of the smartphone-based dietary assessment app **Traqq**. Balancing the required level of accuracy and user-friendliness posed the following main challenges in the development of the app related to decisions on 1) data entry (*i.e.*, selecting the most accurate method for food identification and portion size quantification), 2) food composition data (*i.e.*, selecting an accurate database and creating a full-fledged food list), 3) customization options (*i.e.*, flexibility in food list, portion size quantification, and recipes), and 4) validation (*i.e.*, against traditional methods and/or independent measures)<sup>3,50</sup>. During the literature review, five validated and fully automated, smartphone-based, dietary assessment tools developed for research were identified<sup>3</sup>, namely My Meal Mate<sup>4</sup>, Electronic Dietary Intake Assessment (eDIA)<sup>7</sup>, Easy Diet Diary<sup>8</sup>, Electronic Carnet Alimentaire (e-CA)<sup>5</sup>, and Eat and Track (EaT)<sup>6</sup>.

Owing to the level of automatization of these five dietary assessment apps as well as this app, researcher burden and costs substantially decreases while data completeness increases compared to traditional dietary assessment methods. Additionally, this app, in turn, differs from the five existing dietary assessment tools in terms of flexibility. Specifically, whereas existing apps are all based on the food record method, this app can be used as a food record as well as a recall. Moreover, whereas the design of these apps is fixed, **Traqq** has the major advantage that it can be modified to fit different research purposes (*e.g.*, dietary assessment method, food list, sampling schemes, additional questions)<sup>3,50</sup>. Conversely, other existing dietary assessment apps contain valuable features, which are not implemented in the app (yet). To illustrate this point, some apps allow the user to take photographs of their food for food recognition and portion size estimation such as the semi-automated, technology-assisted dietary assessment (TADA) system<sup>51,52</sup>.

Participants in the usability study also indicated that the use of photographs could be a valuable

addition to aid portion size estimation. However, there were still too many challenges to be addressed to implement such a feature at this stage, *e.g.*, specifying and guiding with respect to the photographic angle (*i.e.*, to assess depth), the need for a reference maker (*i.e.*, to correct for sizes and colors), the essential before and after photo (*i.e.*, to assess consumed amounts), and on how to process recipe dishes. Due to these technical challenges, the existing image-based dietary assessment apps are still semi-automated, which means manual image review must be done by the user, the researcher, or both<sup>51,52</sup>. Technological advances, such as crowdsourcing and machine learning, have the potential to improve the use of food images for dietary assessment<sup>53,54</sup>. In the future, these options will be explored to further improve the app. The developmental process of the app was characterized by various critical steps. First, a formative research step was completed wherein the scientific concepts underpinning the rationale for app creation facilitated decision-making in setting up the general outline of the app.

During this stage, special attention was paid to the selection of the FCDB and the selection of the PSEA—aspects that both directly influence data accuracy<sup>21</sup>. Regarding the FCDB, as the app has originally been developed for use in the Netherlands, its food list is based on the Dutch FCDB, NEVO<sup>3</sup>. In the future, the aim is to further develop the app for international use, which requires more extensive food composition data as many foods are country-specific. Currently, no international FCDB exists yet and if existent, its use might have been limited. More specifically, as the Dutch food list already contains 2,389 food items, the implementation of an international food composition table, *e.g.*, for 5 countries would probably multiply this number of food items by about 5 and negatively affect the searchability of foods and consequently, the app's usability. Therefore, country-specific food lists will probably be most valuable and often also preferred by professionals<sup>55</sup>.

This is facilitated by the app as it enables the import of alternative food lists and thus linkage to different (international) food composition tables. Regarding the portion sizes, there are multiple options available to support the accuracy of the estimates, *e.g.*, use of image booklets, referent objects, and/or textual portion size suggestions<sup>26</sup>. In view of user-friendliness, direct implementation of a PSEA in the app is preferred over using a PSEA alongside the app (*e.g.*, image booklet, referent objects). During the development of the app, the decision was made to facilitate portion size quantification by offering the opportunity to enter portion sizes using portion size suggestions and entry in grams. Portion size suggestion are based on the only available Dutch portion size database<sup>56</sup>. Although Dutch dietary assessment tools such as Compl-eat and Eetmeter also rely on this database<sup>13,17</sup>, it needs to be noted that this portion size database dates from 2003, and tableware sizes have since increased<sup>57</sup>. Using this database may therefore underestimate food intake.

Currently, the portion size database is being updated by the Dutch National Institute for Public Health and the Environment (RIVM), the Dutch Nutrition Center, and Wageningen University and Research<sup>58</sup>, which will eventually be used to update the portion size suggestions in the app. Discrepancies between the old and new portions will be mapped and adjusted where needed. Although the use of portion size images (*i.e.*, a series of images portraying different amounts of a selected food) may be a good alternative for text-based portion size suggestions<sup>59</sup>, research has



shown that the accuracy of portion size estimation is highest when a series of portion size images is presented at once, instead of one image at a time<sup>45,60,61</sup>. Generally, currently available smartphones have relatively small screens, which limits the presentation of a series of images. Although new technologies facilitate the use of interactive portion size graphics wherein amounts of food on a virtual plate or cup can be increased or decreased by using a slider<sup>62</sup>, these techniques are relatively new and still need to be thoroughly evaluated to assess their accuracy.

Another critical step in the development of the app included the involvement of experts and intended end-users. Although not often incorporated in the developmental process of tools (or not described)<sup>11,12</sup>, feedback from experts—as well as intended end-users—is crucial<sup>63</sup>, allows maximization of usability, and maintains the required level of accuracy. The feedback of the intended end-users was particularly helpful in the final design of the **My Dishes** function. Overall, the users were satisfied with the possibility to create their own dishes. However, they did struggle with some of the procedures, for instance, although the function would automatically save data, this was not visible to the user. Therefore, many users kept searching for the **Save** button and got stuck, afraid to go back and lose their input. Based on these kinds of feedback, the function was improved to better fit the expectations of the user.

To conclude, **Traqq** is an innovative app with many advantages over existing apps and web-based tools. However, there are still various limitations. As the app still relies on self-report, self-report-related measurement errors still exist (*e.g.*, memory bias (*i.e.*, in case of recall), social desirability bias, and food intake modifications (*i.e.*, in case of food records), inaccurate portion size estimations (*i.e.*, in both))<sup>1</sup>. In the coming years, recently launched novel technologies will be explored to further advance the app, *e.g.*, by exploring the value of implementing features such as barcode scanners, voice recording, chatbots, and images, which could improve food identification and portion size estimation. Possibilities to connect with other apps (*e.g.*, activity trackers, sleep trackers) and devices (*e.g.*, accelerometers, heart rate monitors, chewing sensors) are being explored as well. Finally, the backend is also being subjected to further development *e.g.*, through the expansion of sampling options.

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#### **DISCLOSURES:**

The authors have nothing to disclose.

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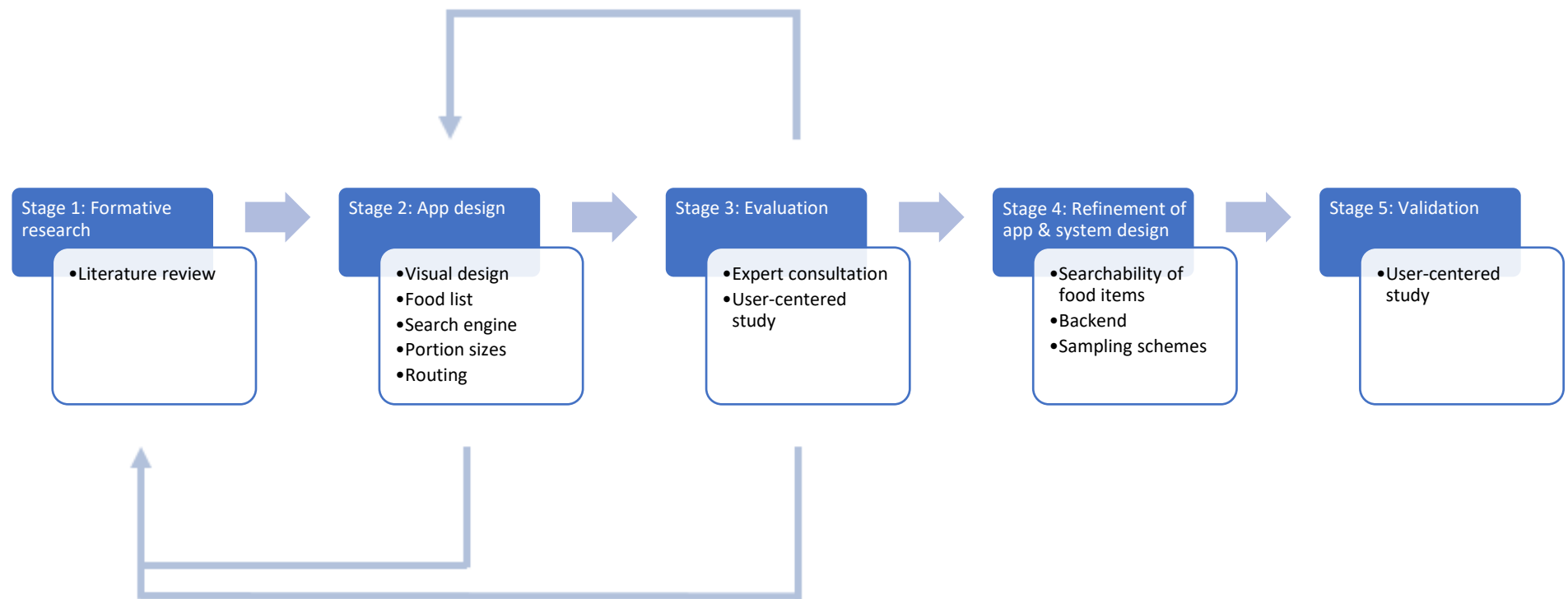
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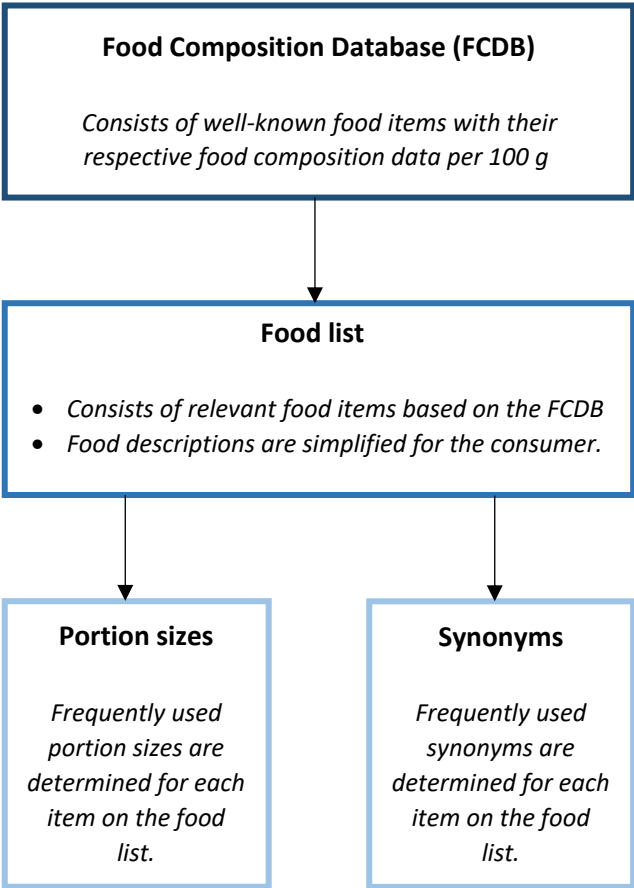
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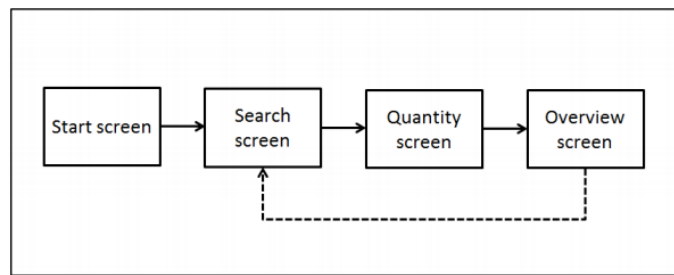
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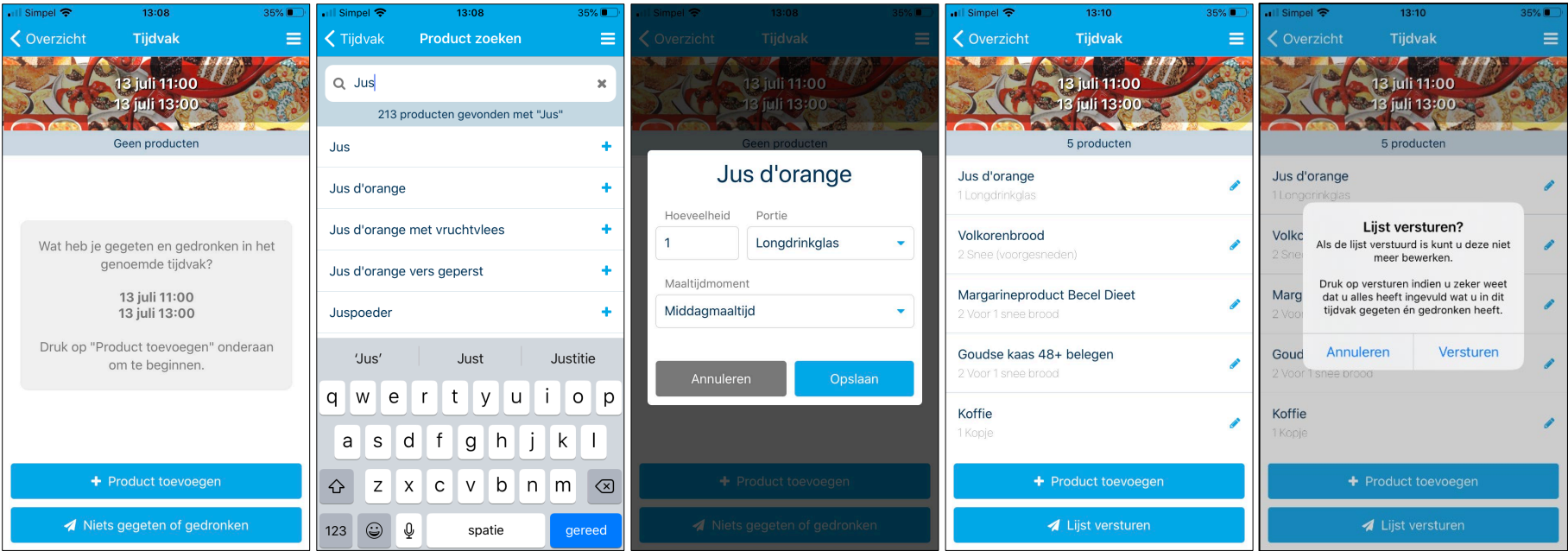
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A

B

C

D

E

Total ( <i>n</i> =22)	
Gender	
Male (%)	36.4
Female (%)	63.6
Mean age (mean, SD)	48.1 (17.2)
Educational level	
Low (%)	0
Medium (%)	45.5
High (%)	54.5
Smartphone type	
Android (%)	63.6
iOS (%)	36.4
Smartphone experience	
Shorter than 6 months (%)	4.5
Between 6 months and 1 year (%)	0
Longer than 1 year (%)	95.5
SUS (mean, SD)	79.4 (15.1)

Name of Material/Equipment	Company	Catalog Number	Comments/Description
ASA24 Portion size picture book	American National Cancer Institute	na	The portion size image database as used in the ASA24-tool
Atlas.ti v8	ATLAS.ti Scientific Software Development GmbH	na	Qualitative data analysis software for research
Compl-eat	Wageningen University	na	The portion size suggestions database as used in the Compl-eat 24hR module
iOS screen record function	Apple Inc.	na	Build-in iOS feature to make screen recordings
NEVO (version 2016/5.0)	RIVM	na	Dutch Food Composition Database
Qualtrics	Qualtrics XM	na	Online survey tool that can be used to implement additional questions in Traqq
Recordable	Invisibility Ltd.	na	Android app to make screen recordings
SPSS version 24.0	IBM Corporation	na	Statistical software
System Usability Scale (SUS)	na	na	Validated questionnaire to assess a system's usability

Dear Editor and reviewers,

Thank you very much for reviewing our manuscript. We very much appreciate the investment of your time and the comments provided. Based on the comments we reviewed our manuscript and made the appropriate adjustments. Please find enclosed an updated version of our manuscript. Within this letter we would like to take the opportunity to further address the comments:

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**Editorial comments:**

Changes to be made by the Author(s):

*1. Please take this opportunity to thoroughly proofread the manuscript to ensure that there are no spelling or grammar issues. Please define all abbreviations at first use.*

The text has been thoroughly proofread by all the authors to check for spelling and grammar issues.

*2. Please revise the text to avoid the use of any personal pronouns (e.g., "we", "you", "our" etc.).*

The text has been altered to avoid the use of these pronouns.

*3. Please ensure that all text in the protocol section is written in the imperative tense as if telling someone how to do the technique (e.g., "Do this," "Ensure that," etc.). The actions should be described in the imperative tense in complete sentences wherever possible. Avoid usage of phrases such as "could be," "should be," and "would be" throughout the Protocol. Any text that cannot be written in the imperative tense may be added as a "Note." However, notes should be concise and used sparingly. Please include all safety procedures and use of hoods, etc. "Notes" should only be used to provide extraneous details, optional steps, or recommendations that are not critical to a step. Any text that provides details about how to perform a particular step should either be included in the step itself or added as a sub-step. Please consider moving some of the notes about the protocol to the discussion section. Also, as you revise using the imperative tense, please consider splitting your protocol into different sections giving instructions for participants and researchers.*

The text has been altered to the imperative tense. Many of the notes have been altered, they are now either included in the step itself or moved to the introduction, results or discussion depending on where it fit best. Finally, we divided the protocol into 'use by researchers' and 'use by participants'. The 'use by researchers' is also divided into administrator and actual researcher usage. Hopefully, the revised version of the protocol is clear and easier to follow.

*4. Please note that your protocol will be used to generate the script for the video and must contain everything that you would like shown in the video. Please add more details to your protocol steps. Please ensure you answer the "how" question, i.e., how is the step performed? Alternatively, add references to published material specifying how to perform the protocol action. Please add more specific details (e.g. button clicks for software actions, numerical values for settings, etc) to your protocol steps. There should be enough detail in each step to supplement the actions seen in the video so that viewers can easily replicate the protocol.*

The protocol is altered in an attempt to make it easier to replicate, buttons are portrayed in bold text to make them more distinct. In some cases the result of the action is mentioned in the notes, this way the person following the protocol can ensure the steps are performed correctly.

*5. JoVE policy states that the video narrative is objective and not biased towards a particular product featured in the video. The goal of this policy is to focus on the science rather than to present a technique as an advertisement for a specific item. To this end, we ask that you please reduce the*

number of instances of "Traqq" within your text. The term may be introduced but please use it infrequently and when directly relevant. Otherwise, please refer to the term using generic language. The name Traqq is replaced as much as possible with generic terms (i.e., the app, the system).

6. JoVE cannot publish manuscripts containing commercial language. This includes trademark symbols (™), registered symbols (®), and company names before an instrument or reagent. Please remove all commercial language from your manuscript and use generic terms instead. All commercial products should be sufficiently referenced in the Table of Materials and Reagents.

For example: Atlas.ti (Atlas.ti v8, Atlas.ti GmbH), etc.

Atlas.ti is moved to the Table of Materials and no longer mentioned by name in the text. The same has been done for the screen recording features/apps.

7. After including a one line space between each protocol step, highlight up to 3 pages of protocol text for inclusion in the protocol section of the video. This will clarify what needs to be filmed.

Throughout the entire protocol a one line space has been included. Following, we highlighted 3 pages for inclusion in the video.

8. Please ensure that the references appear as the following: [Lastname, F.I., LastName, F.I., LastName, F.I. Article Title. Source. Volume (Issue), FirstPage–LastPage (YEAR).] For more than 6 authors, list only the first author then et al. Do not abbreviate journal names.

All references have been checked. The JoVE Endnote Style has been used to ensure correct citations.

9. Please revise the table of the essential supplies, reagents, and equipment. The table should include the name, company, and catalog number of all relevant materials in separate columns in an xls/xlsx file. Please sort the Materials Table alphabetically by the name of the material. In your case, you could include softwares and any other equipment or questionnaires you may have used to develop Traqq.

The software we used in the developmental process has been moved from the protocol to the Table of Materials. The tools that only have been examined and that are used as examples are still in the text. We hope that this is as desired.

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#### **Reviewers' comments:**

##### **Reviewer #1:**

Manuscript Summary:

General comment

The researchers wish to develop a flexible and accurate smartphone application suitable with various research purposes in the Netherlands. The team designed a protocol to develop this smartphone solution and evaluate its usability based on user acceptance tests and the involvement of experts specialised in dietary assessment. This protocol is described in this nicely written paper that should be appealing to research teams looking for an ubiquitous, consumer-centric, validated dietary assessment tool to be used in research projects conducted in the Netherlands.

Major Concerns:

- 22 Keywords: Consider removing FFQ from keywords. To my understanding the app is developed for prospective dietary assessment or 24 hour (or less) dietary recall

Indeed, the app cannot be used as a FFQ. Therefore the keyword is redundant and deleted.

- 40/69 Main research purposes are not described in the abstract but can be presented in the introduction. As the team wishes to develop an app for "various" research purposes, more details will have to be presented. It may be needed to describe a few of them (will be the app be used in nutrition

*research, epidemiological programs, behavioral research, clinical research?). Further references may be needed.*

We included extra details about possible research aims in lines 84-89. As the app is so flexible it can be used for many purposes, but first it has to be validated. This is being done at the moment and we are awaiting the results.

Minor Concerns:

Abstract

*- 42 Consider "eating occasion" instead of meal, unless snacks are considered as meals in the app*

We agree that this is a better description than meal moment. We changed it in line 42 and any other place in the text that mentioned meal moment.

*- 180 the app is available for both iOS and Android smartphones. This can be mentioned in the abstract.*

We included it in line 31.

Protocol

*- 110 Reference 26, 35, 36 can be cited already*

Indeed, we must have overlooked this. The references for all the named tools are now included. The actual text has been moved to lines 592-596 based on editorial comments.

*- 112 What is (are) the performance indicator(s)? Food identification (exact match, close match, poor match?); availability of nutrient data? ; Accuracy of the food composition database? Relevance of the nutritional outputs? If this evaluation of the performance has been published, please add the reference.*

This evaluation will not be published. We included many performance indicators such as data entry method, searchability of food list, display of search results, reliability of food composition database, portion size estimation aids, etc. As the required features depend on the tool to be developed we mentioned a few examples in the text and discussed the most important ones in the results/discussion. Unfortunately, we could not implement all the results of the inspection due to journal and protocol restrictions.

*- 212 Brooke's SUS: Consider citing reference 23 already.*

The reference has been included.

*- 337 Consider adding a rationale for the use of Compl-eat in the introduction. Reference 26 can be cited here as well.*

Based on the editorial comments we removed the mentioning of Compl-eat from this section. Therefore, we decided not to add the rationale in the introduction as we are not allowed to favor one tool over the other. However, the reason that we mentioned Compl-eat was that it is a tool developed by WUR that facilitates in-depth nutrition calculations. However, the data can be analyzed using any type of nutrition calculation software as long as it runs on the Dutch food composition database. This was added in lines 511-512.

*- 375 Will the results of this pilot study be presented in appendix or in a separate communication? if not, more information on the evaluation criteria related to accuracy should be provided here.*

The results of this pilot study will be published separately and have just been accepted for publication. Therefore, we added the reference in line 640 in the section where the results are discussed briefly.

- 490 examples of "additional questions" can be provided. May additional questions be added even when not related to dietary assessment (health, behavior, social)? This could provide perspectives for its conditions of use and regulatory framework in the various research purposes that will be listed.

Traqq is able to link to online survey tools. Therefore, basically every question can be asked via the app. We included a more extensive explanation of this feature in lines 701-706. Of course, in case of large surveys, we would still recommend using the survey tool itself because of usability issues caused by the small screen of a smartphone.

- 524 Please clarify which this should be removed in view of user-friendliness (graphical components could not fit and would not be suitable for a smartphone user).

We understand the confusion and added on the sentence to clarify what we mean with direct implementation in line 801-803.

- 539 Relatively small screens: Yes, but only when compared to computers and tablets.

Agreed, but as Traqq has been developed for use on a smartphone to facilitate real-time data collection this is an important limitation for the use of a series of images in an app. We added an example of a promising technique that could be a good addition in the future in lines 818-821.

- Fig 1: Typo (findability)

Thank you for pointing this out, the typo has been corrected.

- Fig 2: If FCDB - Food composition database: please expand or add acronym in the caption.

FCDB indeed refers to food composition database. The abbreviation is added in the caption and the figure to clarify.

#### Comments

- Excellent English

- Missing list of abbreviations in the reviewer version

- Note to the Editor, is there a reason why the text is highlighted in yellow from line 273 to 335 in the reviewer version?

#### Reviewer #2:

##### Manuscript Summary:

Thank you for the opportunity to review this manuscript: "Iterative development of an innovative smartphone-based dietary assessment tool: Traqq". This manuscript describes the development of a dietary smartphone app that can be used in the Dutch population for dietary assessment. Certainly there is the need for researchers to contribute to this body of literature to ensure that apps are designed upon an evidence base. While the paper is overall well written there are a few areas that require some additional details. Further comments below:

##### Major Concerns:

1. Introduction - could incorporate some more references from the literature such as around the quality of nutrition apps (e.g. see Direito et al, 2014 BMC Public Health doi: 10.1186/1471-2458-14-646; Chen et al, 2015 JMU doi:10.2196/mhealth.4334) to provide greater justification around why the Traqq app fills an existing gap. Perhaps authors might also like to consider how this app is a country/population specific app.

Thank you for suggesting these additional references. We studied both articles but decided not to include them. Although the reviews are very valuable these are focused on commercially available apps with a main focus on the integration of behavior change techniques whereas we focus on apps specifically developed for food intake assessment for research purposes (lines 67-68), thus without

behavioral intervention. We also added additional clarifications and references in lines 64-73. Furthermore, we included the very nice suggestion regarding the country specificness of not only our app, but most of the available apps. This is now nicely in line with the discussion where we come back to this point in lines 80-91.

*2. Methods: the authors have done well in describing the methods for usability and evaluation. However, regarding 2.2 and 2.4, while the authors ended up addressing what Food composition database was used and provided details about portion size estimation in the results section, I do think there could be a little more included in the methods around these processes. Possibly just to rearrange some of the results into the methods so that it is clearer what has been done for replication of the methods, e.g. how the list was shortened and names made clearer. Could the authors also clarify how nutritionally similar the items that were averaged were?*

It is indeed interesting to include more information on this issue. However, due to editorial restrictions we are not able to add more details in the protocol section. Moreover, we had to remove details. However, we do fully agree and moved important details to the results and discussion in an attempt to further clarify the process.

With regard to the final point, we did not average actual food items. In the Dutch food composition database there is always an average option available, this is the one we selected and the specific brand names have been taken out to avoid confusion. This has been clarified in lines 615-617.

*3. Methods - with the portion sizes, it is mentioned in the results there was pilot testing done of the portion size suggestions vs pictures - can this be described in more detail in the methods, and then can the authors provide some of the results about what was the actual preference of the users?*

The results of this pilot study will be published separately and have just been accepted for publication. Therefore, we added the reference in line 478 in the section where the results are discussed briefly.

*4. For those reads not familiar with the Compl-eat 24-hr recall tool, can the authors also elaboration on what portion size suggestions are - provide a few examples.*

Of course, very good point and some examples are included in lines 637-638.

*5. Discussion - authors may not have come across this but Chen et al., 2019, Nutrition doi.org/10.1016/j.nut.2018.05.003 have published previously about the validation of the MyFitnessPal app, and this could be added to the list in line 480-482.*

We are aware of this nice paper. However, we focused on apps designed for research purposes (i.e., with a scientific bases) and therefore MFP was not mentioned here. This detail was not mentioned in the text, but is now added for clarification.

*6. A strength of this study that the authors might like to note is that the app has very much involved health professional as experts in app development (which is a limitation of diet apps from quality evaluation by Chen et al, 2015 JMU doi:10.2196/mhealth.4334) and something that dietitians have also raised previously regarding app design (Chen et al 2016, JMU doi:10.2196/mhealth.6945). Dietitians also prefer country-specific apps to use with their patients.*

These are very good points that indeed could be highlighted more. Therefore, we adjusted the text and included the mentioned references in lines 795 and 825 of the discussion. In addition, we also included the reference to Chen et al, 2015 in the introduction as an additional rationale for the involvement of experts (lines 91-92).

*7. It would strengthen the paper if the authors could consider how the app could be used to support clinical caret (e.g. in nutrition or dietetic counselling) or research, or even how the population could use it independently.*



This is a very good point, but at the moment outside of the scope of this paper. As mentioned Traqq has been specifically developed to improve dietary assessment for research purpose. The system is designed in such a way that the app cannot be used independently. There is no value for independent users as the app does not provide any feedback. Moreover, the app cannot even be used to record food intake without someone sending reporting invitations. Applying the app in practice could be possible in the future, but the system as is does not facilitate nutrition calculations without involvement of WUR (to ensure data quality). However, the current process is not desirable for dietitians for instance, they need to be able to use the system independently. To enable independent use major adjustments need to be done that are not (yet) planned in the near future. We are planning to further develop the app, but aimed for research, so implementing newer techniques, linking to other measurement tools, etc.

Minor Concerns:

*8. On page 2 under 1.2, could the authors please provide references against these web-based tools?*

The references have been added for each tool. However, the section has been moved to the results based on editorial comments (lines 592-596).

*9. Possibly is searchability a more appropriate term to use than findability?*

We agree that searchability is a better description, we changed it in the text.

Again, thank you very much for your time and the review of our work. We hope that the adjustments made are of satisfaction and that our manuscript will be accepted for publication in Journal of Visualized Experiments.

On behalf of the other authors,

Sincerely,

Desiree Lucassen, MSc