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## Who uses food barcode scanner apps and why? Exploration of users' characteristics and development of the Food Barcode Scanner App Questionnaire

Eva HANRAS<sup>a</sup>, Basile CHEVRIER<sup>b</sup>, Géraldine DORARD<sup>a</sup>, Emilie BOUJUT<sup>a,c</sup>

<sup>a</sup> Université Paris Cité, Laboratoire de Psychopathologie et Processus de Santé, F-92100 Boulogne-Billancourt, France

<sup>b</sup> Aix-Marseille Univ, PSYCLE, Aix-en-Provence, France

<sup>c</sup> Cergy Paris Université, INSPE, 78100 Saint-Germain en Laye, France

### Corresponding author:

Eva HANRAS

Université Paris Cité, Laboratoire de Psychopathologie et Processus de Santé, F-92100 Boulogne Billancourt, France

E-mail address: [eva.hanras@etu.u-paris.fr](mailto:eva.hanras@etu.u-paris.fr)

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## **Abstract**

Food barcode scanner apps are increasingly being used to verify food quality. By scanning a product's barcode, they can provide a range of information, including nutritional quality or information on the toxicity of food components. While they seem to be widely used, no study has yet examined their use in the general population. The objectives of this study were therefore twofold: a) to identify who the users of food barcode scanner app are, and b) to evaluate behaviors and cognitions associated with use of these apps through the development and validation of the Food Barcode Scanner App Questionnaire (FBSAQ).

A total of 1626 women (average age of 37.51 years;  $SD = 12.67$ ) from the general population were included in this study, with 25.7% reporting themselves as using at least one food barcode scanner apps. Participants completed questionnaires assessing socio-demographic and health characteristics, the use of health apps, and the FBSAQ, when relevant.

The users of food barcode scanner apps did not differ from non-users in regard to key socio-demographic characteristics, but they were more likely to use healthcare services and other health apps than non-users of food barcode scanner apps. Psychometric analyses allowed validation of the FBSAQ through three factors: pathological use, dietary concerns, and exclusion of unhealthy components.

Data showed that the use of food barcode scanner apps can be beneficial for many individuals, as they help with food choices. However, some user may develop more problematic behaviors, with difficulties in not using these apps.

*Keywords:* food app, food choice, healthy diet, food concern, health concern, comparative study

## **Highlights**

- 25.7% of the female sample population use at least one food barcode scanner app.
- Food barcode scanner apps users visit healthcare professionals more often than non-users.
- The Food Barcode Scanners App Questionnaire (FBSAQ; 14 items) evaluates three factors of food barcode scanner apps usage.
- Some individuals may develop a pathological use of food barcode scanner apps, with difficulty in not scanning before buying or consuming.

## 1. Introduction

Concerns about food quality are growing (1), as people are becoming more aware of the health risks related to certain foods (2), and governmental nutritional information campaigns have boosted this awareness (3–5). In some countries, the introduction of front-of-pack labels (e.g., Nutri-Score; 6) has been proposed to help individuals make healthier food choices. However, in most countries, front-of-pack labeling is not compulsory (6); the industry must choose whether to display such labels. In the interests of transparency, food barcode scanner apps (FBSA) have been developed to facilitate access to information and the adoption of healthier eating habits (7–10).

By scanning the barcode of a food product, such apps provide nutritional properties as well as information on food components. Most apps analyze the list of ingredients and indicate whether they are good, low-, or high-risk for health. Others also offer recommendations for alternative and healthier products, assistance with nutrition professionals, a food diary, and recipes. Between 17% and 25% of adults currently use an FBSA in France (11,12), but the prevalence of its use has not been analyzed in other countries. Most FBSA studies have been conducted to evaluate different designs (13,14) or prevention programs among specific populations (15–17). To date, only one publication (18) has focused on how barcode scanner apps are used by exploring users' perceptions of how these apps are used in the general population.

From analysis of 260 opinions left by users of a food diary and food barcode scanner app (i.e., Fooducate©), it appears that this app had enabled them to eat healthier and to more easily choose foods they can eat with dietary restrictions (e.g., diabetes, allergies, intolerance). By changing their habits, 9% of the users reported losing weight (18). These findings lead us to believe that the use of this app could be recommended for overweight individuals and/or for those who are suffering from a nutritional pathology (e.g., diabetes, celiac disease). However, it is unclear whether these outcomes resulted from the use of food diaries, food barcode scanners, or both. It is, therefore, important to be able to differentiate between the use of these two functionalities, especially as it has been shown that the use of food apps, in general, is not always beneficial to users. For example, in Eikey et al.'s (19) study, 16% of the sample developed an eating disorder as a result of using a food diary app. Moreover, food self-monitoring apps may further encourage some individuals already experiencing dietary difficulties to further tighten their restrictions and thus worsen their disorder (20). Hence, it is necessary to make a clear distinction between the use of a food diary app and that of an FBSA since the objectives of use and repercussions of each may differ.

In summary, the use of a food barcode scanner app seems to be widely democratized. That is, it can help to promote healthier eating habits and thus prevent chronic diseases. Healthcare professionals can, therefore, recommend the use of these apps. However, the use of food apps (overall) may encourage the emergence of eating difficulties. It is, therefore, necessary to evaluate

how and why these apps are used in order to prevent the emergence of potential difficulties linked to their use. The aims of this exploratory mixed study were twofold: a) to identify characteristics of FBSA users and b) to evaluate how these apps are used and what the impacts on user behaviors and cognitions are. First, differences between users and non-users of FBSAs were analyzed according to users' socio-demographics and dietary characteristics, as well as their use of selected health-related apps (i.e., weight control, diet, hygiene, and cosmetics barcode scanners). Second, to explore the behaviors and cognitions associated with the use of FBSA, we developed the Food Barcode Scanner App Questionnaire (FBSAQ) and validated it (21). Finally, the associations between the FBSAQ factors and the data collected (i.e., socio-demographic and dietary characteristics, health-related apps used, modalities of use of the apps) were determined.

## **2. Method**

### ***2.1. Participants and procedures***

Participants were recruited between May 2021 and February 2022 through calls for participation posted on Facebook groups (i.e., food, health, well-being, sport, mutual support, students), forums, and directly from the investigators' social networks. The link to the study was available in the calls for participation. The study was hosted on the anonymous and confidential LimeSurvey platform.

To participate, individuals had to be between 18 and 65 years of age, fluent in French, and female participants could not be pregnant. Before completing the questionnaires, participants were required to read the information note, complete the inclusion criteria, and provide their consent. The research protocol was approved by the research ethics committee of [removed for blind peer review].

A total of 1876 participants were recruited. However, male respondents were excluded due to their small number ( $n = 26$  for food barcode scanner apps users; and  $n = 224$  for non-users of these apps).

### ***2.2. Creation of the FBSAQ***

In total, 14 participants were recruited, of which 69% were female, with a mean age of 42.3 years ( $SD = 13.9$ , ranging from 22 to 64 years). During the interviews, no difference in the use of the FBSA across gender was observed.

Analysis of the interviews revealed three main themes. The first theme, called *use of food barcode scanner apps*, included three subcategories: a) difficulties in not using these apps when shopping or before consuming food, with a potential "addictive" effect evoked in two participants; b) app use behaviors, with a focus on the types of products scanned (e.g., cereals, preserves, fresh products), the places of use (e.g., stores, home, family or friend), and motivations for using these apps (e.g., to eat healthier, to scan any new product); c) food concerns prior or subsequent to app use and

the expressed distrust of industrial products. Based on this theme, 16 items were generated. The second theme, *information provided by food barcode scanner apps*, had two subcategories: a) attention to information provided by apps (e.g., confidence in this information, level of attention paid to caloric intake and food components) and b) changes in food consumed (e.g., exclusion of certain foods due to their composition). Ten items were generated for this theme. Finally, the third theme, called *positive consequences of using food barcode scanner apps*, referred to the subjective improvement of participants' daily lives as a result of using these apps (e.g., healthier life, fewer nutrition-related problems, increase nutrition knowledge). Three items were generated. Overall, the results of the analysis enabled the creation of 31 items on FBSA use behavior and its consequences. Participants were asked to indicate how much they agreed with the items on a five-point scale ranging from 1 (*totally disagree*) to 5 (*totally agree*).

### **2.3. Measures**

An ad hoc questionnaire was constructed specifically for this research. It consisted of four sections: socio-demographics, health, diet, and the use of health apps. The first section assessed gender, age, marital status (i.e., single, married), children (i.e., yes, no), educational level (ranging from *no diploma* to *PhD*, with an additional "other" response where the participant was asked to explain their answer), and professional status (from *student* to *retired*, with an additional "other" response where the participant was asked to explain their answer). The second section assessed height and current weight for BMI calculation, chronic diseases (i.e., yes, no), diseases requiring/associated with dietary control (only self-reported eating disorders were processed for this study), and the frequency of visits to healthcare professionals (from *several times a month* to *less than once a year*). The third section assessed the frequency of organic food consumption (from *only organic food* to *never*). Finally, we asked participants to select from a list the types of apps they use (including diet tracker apps, weight control apps, food barcode scanner apps, and cosmetics and hygiene barcode scanner apps). If participants declared that they used an FBSA, they were required to a) specify the duration of utilization (from *less than six months* to *more than two years*), b) specify the frequency of use (from *less than once a month* to *every day or almost every day*), and c) complete the FBSAQ.

### **2.3. Statistical analysis**

The statistical analysis was performed with the 1.2.5033 version of R Studio software and the 1.6.23.0 version of Jamovi software. FBSA users and non-users were compared across measures (i.e., socio-demographics, clinical and dietary outcomes, and health app use). Chi-square tests and their adjusted standardized residuals (ASR; an absolute value greater than two determined which cells significantly differed from the hypothesis of independence) were used for the categorical data (e.g., gender, academic degree), and Student's *t*-tests for the continuous data (e.g., age, BMI).

Regarding the validation of the FBSAQ (i.e., 31 items), outliers were not removed because they were representative of the variability of the sample (22). Internal structure (21) was examined with principal component analysis (PCA) and confirmatory factor analysis (CFA) on the same sample of FBSA users ( $n = 419$ ) according to the recommendation of Henson and Roberts (23). The PCA was performed after the verification of validity criteria, a Bartlett's test ( $p < .05$ ), and Kaiser-Meyer-Olkin test ( $KMO > .80$ ; (24). Varimax rotation was used with consideration for the theoretical independence of certain items. The number of components was initially determined by the Kaiser-Guttman criterion (eigenvalues  $> 1$ ). Items were deleted when: a) their loading was less than  $|0.40|$  on all factors or greater than  $|0.40|$  on several factors (25), b) their uniqueness was greater than  $.60$  (26), and c) their theoretical distribution was not consistent. The reduction in the number of factors was conducted according to the items deleted. When a single item saturated a factor, we chose to delete the item (26). The internal consistency of the factors was estimated with Cronbach's alpha.

The CFA was conducted according to the model obtained in PCA. As the PCA was performed by processing the data continuously, the same processing was used for the CFA (27). Maximum likelihood with robust standard errors (MLR) was used. The adjustment of the model was analyzed with the Standardized Root Mean Square Residual ( $SRMR < .09$ ), the Root Mean Square Error of Approximation ( $RMSEA < .07$ ), the Comparative Fit Index ( $CFI > .95$ ), and the Tucker-Lewis Index ( $TLI > .95$ ; (28).

From an exploratory perspective, marital status, parenting, chronic disease, eating disorder, and the use of other health-related apps were compared with Mann-Whitney tests according to the factors obtained from the FBSAQ. Moreover, academic degree, professional status, healthcare frequency, organic food consumption, and the frequency and duration of the use of food barcode scanner apps were also compared according to the FBSAQ factors. For this, Kruskal-Wallis with Dwass-Steel-Critchlow-Fligner post hoc tests were performed.

### **3. Results**

#### **3.1. User characteristics of FBSA**

Participants of quantitative approach comprised 1626 French females, with a mean age of 37.51 years ( $SD = 12.67$ , ranging from 18 to 65 years). Of the participants, 25.77% reported downloading and using at least one FBSA and 74.23% do not use this type of mobile app.

The statistical analyses (see Table 1) showed that FBSA users and FBSA non-users do not differ in terms of age ( $t(1624) = -1.30, p = .192$ ), marital status ( $\chi^2(1) = 1.19, p = .276$ ), having children ( $\chi^2(1) = 0.05, p = .824$ ), academic degree ( $\chi^2(2) = 3.16, p = .206$ ), professional status ( $\chi^2(4) = 2.68, p = .612$ ), chronic disease ( $\chi^2(1) = 0.01, p = .944$ ), current BMI ( $t(1624) = -1.51, p = .132$ ), or self-declared eating disorders ( $\chi^2(1) = 0.03, p = .862$ ). However, FBSA users more frequently



visited healthcare professionals than FBSA non-users ( $\chi^2 (3) = 13.31, p = .004$ ). They also more frequently used other health-related apps, such as for weight loss ( $\chi^2 (1) = 16.20, p < .001$ ), dieting (i.e., food diary and diet management;  $\chi^2 (1) = 15.54, p < .001$ ), or cosmetics and hygiene products quality control ( $\chi^2 (1) = 536.91, p < .001$ ) than FBSA non-users. Indeed, 55.8% of participants reported scanning food, hygiene products, and cosmetics at the same time.

Most users of FBSA indicated using only one app (79.2%), but some reported use of two apps (15.5%) or more (5.2%). Most users had been using apps for more than two years (43.2%), while 26.6% did so for less than one year. Regarding their use of apps, 45.6% reported using them less than once a month, 34.1% several times a month, 16.2% several times a week, and 4.1% every day or almost every day.

### **3.2. Validation of the FBSAQ**

A series of ten PCA with varimax rotation were performed on the 31 items of the FBSAQ among 419 FBSA users. Verification of the criteria for use of the PCA showed that the 31-item supported the factorial analysis (KMO = .92; Bartlett sphericity test:  $\chi^2 (465) = 5760.07, p < .001$ ). The first PCA model included seven factors with eigenvalue higher than 1 into which the 31 items were distributed, explaining 61.2% of the variance. However, one item had to be removed, as its cross-load on two factors with loadings was higher than .40. This procedure was repeated until all items had a loading higher than .40 on a single factor, the uniqueness of each item was lower than .60, and the number of factors was reduced each time a single item saturated a factor. Thus, 14 items were deleted, and four factors were kept.

The ninth PCA model included four factors, into which the 17 items were distributed, explaining 63.8% of the variance. However, the last factor, which included three items, was theoretically inconsistent ("I sometimes scan a product before consuming it even if I have already scanned it in stores"; "Since I have been using the apps, I have had fewer problems related to my diet"; "I sometimes scan products when I visit relatives"). This factor also had low internal consistency ( $\alpha = .55$ ), so we decided to remove it.

Finally, the last PCA model included three factors, into which the 14 items were distributed, explaining 65.1% of the variance (see Table 2). In this model, the criteria for use of the PCA were verified (KMO = .91; Bartlett sphericity test:  $\chi^2 (91) = 2\,945.29, p < .001$ ). The internal consistency was good for each factor ( $\alpha > .80$ ; see Table 2), and the CFA fit solution was satisfactory:  $\chi^2 (74) = 207.63, p < .001$ , CFI = .94, RMSEA = .066[.056–.076], TLI = .93, and SRMR = 0.041. Factor 1 was comprised of five items, such as "It is difficult for me to buy a product without scanning it", with loadings varying from .77 to .82 ( $p < .001$  for each loading). This assessed the need of individuals to scan a food before buying or consuming. However, a dimension of dependence/addiction appeared in the grouping of these items with the difficulty or even impossibility of not scanning the products.

This factor was therefore called *pathological use*. Factor 2 was comprised of six items, such as "I use the app because I am concerned about the quality of my food", with loadings varying from .61 to .79 ( $p < .001$  for each loading). It measured food mistrust, food concerns, and use of these apps to eat healthy, and was therefore named *food preoccupation*. Factor 3 was comprised of three items, such as "Since I started using the app, I have excluded products that are too salty", with loadings varying from .75 to .79 ( $p < .001$  for each loading). It assessed the exclusion of products containing too much salt, sugar, or fat, i.e., components known to be unhealthy. This factor was named *the exclusion of unhealthy components*.

Significant correlations ( $p < .001$ ) were observed between *pathological use* and *food preoccupation* ( $r = .52$ ), between *pathological use* and *exclusion of unhealthy components* ( $r = .56$ ), and between *food preoccupation* and *exclusion of unhealthy components* ( $r = .59$ ).

### **3.3. Comparisons of the data according to the FBSAQ subscales**

#### **3.3.1. Socio-demographic, dietary, and health-related apps usage characteristics**

The statistical analyses showed no differences in terms of marital status, educational level, and use of weight control apps for the FBSAQ subscales (see Table 3). Contrastingly, the FBSAQ subscale scores were influenced both by professional status (Kruskal–Wallis  $\chi^2(4) = 22.3, p < .001$  for *pathological use*; Kruskal–Wallis  $\chi^2(4) = 15.7, p = .003$  for *food preoccupation*; Kruskal–Wallis  $\chi^2(4) = 17.1, p = .002$  for *exclusion of unhealthy components*) and parenting ( $U = 16831, p < .001$  for *pathological use*;  $U = 16409, p < .001$  for *food preoccupation*;  $U = 17350, p < .001$  for *exclusion of unhealthy components*). Specifically, unemployed participants had higher scores on all subscales compared to students ( $p$  ranging from .005 for *food preoccupation* to .017 for *exclusion of unhealthy components*). Sick leave participants had higher scores on the *pathological use* subscale compared to students and employees ( $p$  values  $< .001$  and .018 respectively). Retirees had higher scores on the *exclusion of unhealthy components* subscale than students ( $p = .017$ ). Additionally, participants who were parents had higher scores on all three factors of FBSAQ compared with those who were not parents.

Concerning both the *pathological use* and *food preoccupation* subscales, participants who had self-reported eating disorders ( $U = 8675, p = .034$  for *pathological use*;  $U = 8453, p = .018$  for *food preoccupation*), those who used a diet tracker app ( $U = 7611, p = .017$  for *pathological use*;  $U = 7462, p = .011$  for *food preoccupation*), and those who used a cosmetics and hygiene barcode scanner app ( $U = 18781, p = .019$  for *pathological use*;  $U = 17148, p < .001$  for *food preoccupation*) had higher scores than those who did not have eating disorders and those who did not use a diet tracker app or a cosmetic and hygiene barcode scanner app.

Regarding the *pathological use* and *exclusion of unhealthy components* subscales, the participants with chronic diseases ( $U = 11651, p = .019$  and  $U = 11575, p = .016$ , respectively) and

those who frequently consumed organic foods (see Table 4) had higher scores than participants without chronic diseases and those who rarely consumed organic foods.

### 3.3.2. Frequency and duration use of FBSA

Kruskal–Wallis tests revealed significant differences in frequency of use of FBSA for *pathological use* (Kruskal–Wallis  $\chi^2(3) = 123.5, p < .001$ ), *food preoccupation* (Kruskal–Wallis  $\chi^2(3) = 83.7, p < .001$ ), and *exclusion of unhealthy components* (Kruskal–Wallis  $\chi^2(3) = 60.4, p < .001$ ) subscales (see Table 4). Specifically, the participants who used FBSA either several times a week or on a daily basis had higher scores on the *pathological use* subscale than those who used them less than once a month ( $p < .001$  for each post hoc analyses) or several times a month ( $p < .001$  for each post hoc analyses). However, no difference was observed in the *pathological use* scores between those who used them several times a week or every day or almost every day ( $p = .582$ ).

Concerning *food preoccupation* and *exclusion of unhealthy components* subscales, the participants who used FBSA less than once a month had lower scores than those who used these apps more frequently ( $p < .001$  for each post hoc analyses). Additionally, the participants who used these apps several times a month had lower scores on both factors than those who used them several times a week ( $p = .047$  and  $p = .013$ , respectively) Furthermore, the participants who used apps several times a month had lower scores on the *food preoccupation* subscale than those who used them almost daily ( $p = .008$ ).

Regarding the duration of use of FBSA, only one difference was observed in the *food preoccupation* (Kruskal–Wallis  $\chi^2(3) = 15.80, p = .001$ ) subscale. Participants who had used apps for more than two years had higher scores on the *food preoccupation* subscale than those who had been using them for less than six months ( $p = .002$ ).

## 4. Discussion

From an exploratory perspective, the aims of this study were twofold: a) to identify the characteristics of users of FBSA and b) to explore how these apps are used, in regard to their impact on behaviors and cognitions, using the development and the validation of the FBSAQ, which was constructed on the basis of research interviews. This study is, to our knowledge, the first to focus on such topics.

As for the first objective, FBSA users did not differ from FBSA non-users in regard to main socio-demographic characteristics. However, they did consult health professionals more often, despite not reporting more chronic diseases than FBSA non-users. Previous literature has shown that health-conscious individuals tend to visit health professionals more regularly in order to be reassured (29,30). The results of the present study therefore suggest that users of FBSA are more concerned about their health than FBSA non-users. Relevant to these results, several studies have found that health concerns are associated with a desire to eat healthier and with concerns about food quality (31–

33). The use of FBSA may thus allow some users to regulate their health anxiety by controlling the quality of their food intake, whether by adopting an organic diet or by checking the food components of processed products. However, it is also possible that the use of these apps contributes to the development or reinforcement of health-related concerns in individuals who did not have any (or had very few) before using these applications. Longitudinal studies are needed to identify the causal mechanism of the relationship between health concerns and the use of barcode scanner apps.

Individuals concerned about the quality of their diet may fear gaining weight, as being overweight is associated with somatic and physical complications (34–36). Thus, it is not surprising to find that a significant number of FBSA users also use apps related to diet tracking and weight loss, while no difference in BMI was observed between users and non-users of FBSA. These behaviors can probably be attributed to a desire to maintain good health by preventing obesity. However, it is also possible that these behaviors may be associated with dietary difficulties expressed through strict control over diet and weight. Indeed, the pursuit of optimal health through diet has been associated with orthorexia nervosa (37). Individuals with orthorexia exclude all foods they consider "bad" from their diet. These food choice rigidities can be brought on by reading food labels and, now, by scanning products with an app. While further studies are needed to better identify the motivational profiles associated with the use of FBSA, it is possible that a portion of these individuals also engage in health-related behaviors focused on interests other than food in order to promote optimal health (e.g., use of hygiene and cosmetic barcode scanner apps).

The second objective led to the validation of the FBSAQ, which was constructed on the basis of research interviews to assess the cognitions and behaviors associated with FBSA use. The FBSAQ presented high reliability and an acceptable three-factor structure, which gave evidence of validity (19). This French-language questionnaire was composed of 14 items divided into three factors: *pathological use* (i.e., difficulty in not scanning food products before buying or consuming them; five items), *food preoccupation* (i.e., concern about the quality of processed foods; six items), and *exclusion of unhealthy components* (i.e., exclusion of products considered unhealthy; three items). Theoretically, the item that refers to the exclusion of products containing additives (i.e., item 10) in the *food preoccupation* factor could have been found in the *exclusion of unhealthy components* factor, but this item focuses on components officially recognized as being bad for health. Fats, sugar, and salt have long been considered dangerous, but this is not true for additives. Indeed, following the National Nutrition and Health Program (PNNS) established in 2001 in France, health messages such as, "For your health, avoid eating too much fat, too much sugar, and too much salt," were included in food advertisements to encourage individuals to restrict these components of their diets (38). It is, therefore, possible that the *exclusion of unhealthy components* factor is the result of preventive health behaviors inculcated by government policies. From this perspective, the item for the exclusion of

additives could saturate the *exclusion of unhealthy components* factor in countries that have not disseminated this type of health message.

Although the use of FBSA seems favorable for the prevention of certain chronic diseases (i.e., exclusion of "dangerous" components), it appears that some individuals may develop pathological use of them, as evidenced by the first factor, *pathological use*. The participants who scored higher on this factor included those who reported having an eating disorder, chronic illness, sick leave, and more frequent visits to healthcare professionals. It is therefore likely that individuals with health issues use these types of apps in a rigid and problematic way in order to address anxiety related to their health. Similarly, participants who consumed more organic products and those who used food barcode scanner apps for cosmetic and hygiene products also scored higher in regard to pathological use factors. These behaviors may reflect a desire to use and consume only products that are considered healthier. Thus, this factor appears to be associated with health concerns, and special attention should be paid to these user profiles in order to prevent potential difficulties related to the use of these apps. Indeed, during the semi-structured interviews, some participants mentioned an "addictive" effect from scanning products. These results were also evident in the present study, where users feel the need to scan products before purchasing or consuming them. Individuals who pathologically used these types of apps tended to use them every day or almost every day, once again highlighting the difficulty of limiting dependency on use of these apps. Similarly, (39) showed that the frequency of app use could predict problematic smartphone use. Further investigations are therefore needed to assess whether food barcode scan app use can also be linked to problematic smartphone use.

The development of apps has forced food industry professionals to change recipes for their food products in order to make them healthier and entice consumers into purchasing them (10). However, some individuals' dependency on these apps raises several questions. These individuals believe they are consuming selected "good" foods. However, the data provided to consumers varies considerably from app to app, even though most apps use the same database to evaluate foods. For example, one app may consider a scanned food to be "good" for health, while another may indicate that the same product is "bad." These disparities depend on the evaluation criteria defined by the app developers while programming data processing algorithms, which are not always based on scientific data or verified knowledge of the toxicity of certain food components (10). For example, some apps may warn of the danger of certain additives even though they are authorized by European authorities. The veracity of the information transmitted to users is therefore uncertain and studies are needed to assess their relevance in order to propose apps recommendations.

The results of this study should be interpreted with caution in light of observed limitations. First, this study was conducted entirely with female participants. While this allowed a large sample of female users of FBSA and the ability to control for gender effect, it is also necessary to replicate

such a study with men in order to assess whether the present results can be generalized to include this population. Second, the sample population was mostly recruited on the internet, and the individuals in the sample were potentially particularly interested in food. Other means of recruitment should therefore be used in future studies to obtain a less-biased representation. Third, factor analyses were conducted on the same sample (as recommended by Henson and Roberts; 21), but these analyses should be replicated with another group to confirm the structural validity of the obtained data. Finally, the study was conducted with only a French sample; therefore, cultural effects on the use of food barcode scanner apps could not be excluded and should be further investigated.

In order to prevent problematic behaviors associated with the use of FBSA (e.g., difficulty stopping use), it is necessary to continue the present investigation. Specifically, health concerns (i.e., health anxiety), pathological concerns about food (i.e., orthorexia nervosa), and the adoption of other health behaviors by users of FBSA should be investigated. Such research would provide insight into why some individuals exhibit problematic use. This would also allow the implementation of preventive measures against the misuse of these apps, both for the general public and for health professionals. Additionally, it is also necessary to evaluate the real impact of the use of these apps on the quality of food in order to determine if their use could be the subject of public health recommendations, such as Nutri-Score ratings (i.e., logo rating products according to their nutritional quality). This would require comparison of the quality of products purchased by users of these apps with those of non-users by forming matched groups based on socio-demographic and health concern variables.

## **5. Conclusion**

This study presents the main characteristics of the users of food barcode scanner apps compared to non-users, as well as the main cognitions and behaviors associated with the use of these apps. These apps seem to allow consumers to make choices regarding their food purchases and food consumption. However, it remains to be determined whether the use of these apps actually leads to a healthier diet. Moreover, they may also have potentially harmful effects, making it difficult or impossible for some people not to scan the food products they consume. While further studies are needed to better identify individuals who may develop the pathological use of these apps for the implementation of primary prevention campaigns, we offer a questionnaire to assess the usage of these apps that health professionals have already prepared for implementation. Indeed, professionals (e.g., doctors, nutritionists, dieticians) can already use this questionnaire to assess their patients' use of these apps, especially if the professionals have recommended their use. If it appears that some patients are finding it difficult to stop using these apps, healthcare professionals can provide them with targeted assistance.

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Table 1.

Group comparisons for socio-demographic, health, and dietary data according to the food barcode scanner apps use ( $N = 1626$ ).

	Users ( $n = 419$ )	Non-users ( $n = 1207$ )	Comparisons	
			$t/\chi^2$	$p$
Age, Mean ( $SD$ )	36.81 (12.38)	37.75 (12.77)	-1.30	.192
Marital Status, % ( $ASR$ )			1.19	.276
<i>Single</i>	28.9 (-0.82)	71.1 (0.48)		
<i>Married</i>	31.9 (0.55)	68.1 (-0.33)		
Child, % ( $ASR$ )			0.05	.824
<i>Yes</i>	51.1 (-0.17)	51.9 (-0.17)		
<i>No</i>	48.9 (0.17)	48.1 (-0.10)		
Academic degree, % ( $ASR$ )			3.16	.206
< <i>Bachelor</i>	10.2 (0.05)	10.1 (-0.03)		
<i>Bachelor</i>	16.7 (-1.35)	20.7 (0.80)		
> <i>Bachelor</i>	73.1 (0.70)	69.2 (-0.41)		
Professional status, % ( $ASR$ )			2.68	.612
<i>Student</i>	20.6 (1.20)	17.2 (-0.71)		
<i>Employed</i>	62.2 (-0.39)	64.3 (0.23)		
<i>Sick leave</i>	04.1 (0.01)	04.3 (-0.01)		
<i>Unemployed</i>	09.9 (-0.31)	10.6 (0.18)		
<i>Retired</i>	03.1 (-0.55)	03.9 (0.33)		
Healthcare frequency, % ( $ASR$ )			13.31	.004
<i>Several times a month</i>	03.1 (1.12)	02.0 (-0.66)		
<i>At least once a month</i>	16.7 ( <b>2.57</b> )	10.8 (-1.51)		
<i>At least once a year</i>	68.5 (-0.73)	72.6 (0.43)		
<i>Less than once a year</i>	11.7 (-1.21)	14.7 (0.71)		
Chronic disease, % ( $ASR$ )			0.01	.944
<i>Yes</i>	19.8 (-0.11)	20.1 (0.06)		
<i>No</i>	80.2 (0.05)	79.9 (-0.03)		
Current BMI, Mean ( $SD$ )	24.31 (5.76)	24.84 (6.42)	-1.51	.132
Current eating disorder, % ( $ASR$ )			0.03	.862
<i>Yes</i>	13.8 (0.14)	13.5 (-0.08)		
<i>No</i>	86.2 (-0.06)	86.5 (0.03)		
Organic food consumption, % ( $ASR$ )			35.41	< .001
<i>Only organic food</i>	37.7 ( <b>2.31</b> )	29.2 (-1.36)		
<i>At least once a week</i>	34.8 (1.31)	30.0 (-0.77)		
<i>Less than once a week</i>	15.8 (0.03)	15.7 (-0.02)		
<i>(almost) Never</i>	11.7 ( <b>-4.38</b> )	25.1 ( <b>2.58</b> )		
Using diet tracker apps, % ( $ASR$ )			16.20	< .001
<i>Yes</i>	12.4 ( <b>3.11</b> )	06.3 (-1.95)		
<i>No</i>	87.6 (-0.97)	93.7 (0.57)		
Using weight control apps, % ( $ASR$ )			15.54	< .001

<i>Yes</i>	21.5 ( <b>3.19</b> )	13.3 (-1.88)	
<i>No</i>	78.5 (-1.36)	86.7 (0.80)	
Using cosmetics and hygiene barcode scanner apps, % ( <i>ASR</i> )			536.91 < .001
<i>Yes</i>	55.8 ( <b>18.12</b> )	05.1(- <b>10.65</b> )	
<i>No</i>	44.2 (- <b>8.53</b> )	84.9 ( <b>5.03</b> )	

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*Note. ASR:* Adjusted standardized residuals (adjusted standardized residuals in bold reflect significant over- or under-representation); BMI: Body mass index; *SD:* Standard deviation.

Table 2.

*Descriptive analysis and PCA results of the final version of the Food Barcode Scanner App Questionnaire (FBSAQ).*

	Mean	SD	Min	Max	Factors			$\mu$
					1	2	3	
<b>Pathological use</b>								
4. Je scanne tous les produits que je consomme disposant d'un code-barres. <i>I scan all the products I consume that have a barcode.</i>	2.33	1.35	1	5	<b>0.82</b>			0.28
5. Il m'est difficile d'acheter un produit sans l'avoir scanné. <i>It is difficult for me to buy a product without scanning it.</i>	1.72	1.16	1	5	<b>0.80</b>			0.28
9. Il m'est difficile de faire mes courses sans utiliser l'application. <i>It's hard for me to do my shopping without using the app.</i>	1.76	1.20	1	5	<b>0.77</b>			0.32
16. Je ne peux pas m'empêcher de scanner les produits que je consomme. <i>I can't help but scan the products I consume.</i>	2.04	1.29	1	5	<b>0.78</b>			0.29
21. Je scanne tous les produits que j'achète disposant d'un code-barres. <i>I scan all the products I buy that have a barcode.</i>	2.05	1.27	1	5	<b>0.80</b>			0.28
<b>Food preoccupation</b>								
7. J'utilise l'application parce que la qualité de mon alimentation me préoccupe. <i>I use the app because I am concerned about the quality of my food.</i>	4.01	1.15	1	5		<b>0.79</b>		0.35
10. Depuis que j'utilise l'application, j'exclus les produits contenant des additifs. <i>Since using the app, I have excluded products with additives.</i>	3.18	1.35	1	5		<b>0.62</b>		0.42
11. Je continue à utiliser l'application, car il y a des produits que je n'ai pas encore scannés. <i>I'm still using the app because there are products I haven't scanned yet.</i>	3.50	1.42	1	5		<b>0.61</b>		0.52
15. J'utilise l'application parce que je me méfie des produits transformés. <i>I use the app because I am wary of processed products.</i>	4.06	1.22	1	5		<b>0.75</b>		0.38
20. J'utilise l'application, car les produits vendus en supermarchés ne sont pas « sûrs ». <i>I use the app because the products sold in supermarkets are not "safe".</i>	3.21	1.32	1	5		<b>0.65</b>		0.52
27. J'utilise ce type d'application pour manger plus sainement. <i>I use this type of app to eat healthier.</i>	3.60	1.26	1	5		<b>0.65</b>		0.42
<b>Exclusion of unhealthy components</b>								
19. Depuis que j'utilise l'application, j'exclus les produits contenant trop de matières grasses. <i>Since I've been using the app, have excluded products that contain too much fat.</i>	2.58	1.34	1	5			<b>0.76</b>	0.30

22. Depuis que j'utilise l'application, j'exclus les produits trop salés. <i>Since I started using the app, I have excluded products that are too salty.</i>	2.48	1.31	1	5	<b>0.79</b>	0.23
25. Depuis que j'utilise l'application, j'exclus les produits trop sucrés. <i>Since I started using the app, I have excluded products that are too sweet.</i>	2.72	1.44	1	5	<b>0.75</b>	0.31
Eigenvalues					3.61	3.17 2.33
% of variance explained					25.5	22.7 16.6
Cronbach's alphas					.90	.83 .81

*Note.*  $\mu$ : Uniqueness; *SD*: Standard deviation.

Table 3.

Comparison of the Food Barcode Scanner App Questionnaire (FBSAQ) subscales according to the socio-demographic, health, and dietary data.

	Pathological use of apps	Comparisons	Food preoccupation	Comparisons	Exclusion of unhealthy components	Comparisons
	Mean (SD)	U/ $\chi^2$ and post hoc	Mean (SD)	U/ $\chi^2$ and post hoc	Mean (SD)	U/ $\chi^2$ and post hoc
Marital status		U = 16468, $p = .160$		U = 17915, $p = .919$		U = 16541, $p = .183$
Single ( $n = 121$ )	10.7 (5.97)		21.4 (6.28)		8.23 (3.86)	
Married ( $n = 298$ )	9.45 (4.87)		21.7 (5.41)		7.64 (3.30)	
Child		U = 16831, $p < .001$		U = 16409, $p < .001$		U = 17350, $p < .001$
Yes ( $n = 214$ )	10.6 (5.26)		22.8 (5.29)		8.42 (3.33)	
No ( $n = 205$ )	8.99 (5.09)		20.4 (5.80)		7.18 (3.53)	
Academic degree		$\chi^2(2) = 3.36, p = .186$		$\chi^2(2) = 0.95, p = .621$		$\chi^2(2) = 5.03, p = .081$
A. < Bachelor ( $n = 44$ )	11.3 (6.55)		21.0 (7.16)		9.14 (4.24)	
B. Bachelor ( $n = 71$ )	10.2 (4.71)		21.3 (4.80)		7.74 (3.58)	
C. > Bachelor ( $n = 304$ )	9.59 (5.16)		21.7 (5.65)		7.62 (3.30)	
Professional status		$\chi^2(4) = 22.3, p < .001$ C>A,B; D>A		$\chi^2(4) = 15.7, p = .003$ D>A		$\chi^2(4) = 17.1, p = .002$ D,E>A
A. Student ( $n = 86$ )	8.45 (4.53)		20.3 (5.42)		6.80 (3.14)	
B. Employed ( $n = 258$ )	9.74 (5.22)		21.5 (5.85)		7.76 (3.46)	
C. Sick leave ( $n = 18$ )	13.8 (5.60)		24.2 (4.91)		9.00 (3.86)	
D. Unemployed ( $n = 42$ )	11.4 (5.53)		23.6 (5.47)		8.95 (3.61)	
E. Retired ( $n = 15$ )	11.2 (5.66)		22.6 (3.71)		10.0 (3.14)	
Healthcare frequency		$\chi^2(3) = 9.35, p = .025$ B>D		$\chi^2(3) = 1.44, p = .697$		$\chi^2(3) = 0.24, p = .971$
A. Several times a month ( $n = 13$ )	11.5 (6.10)		21.4 (5.65)		8.31 (3.88)	
B. At least once a month ( $n = 70$ )	11.2 (5.75)		21.0 (6.18)		7.89 (3.79)	
C. At least once a year ( $n = 287$ )	9.61 (5.08)		21.8 (5.57)		7.77 (3.40)	

<i>D. Less than once a year (n = 49)</i>	8.61 (4.82)		21.1 (5.53)		7.82 (3.46)	
Chronic disease		U = 11651, <i>p</i> = .019		U = 12591, <i>p</i> = .170		U = 11575, <i>p</i> = .016
Yes (n = 83)	11.0 (5.68)		22.1 (6.30)		8.83 (4.08)	
No (n = 336)	9.52 (5.09)		21.5 (5.50)		7.56 (3.27)	
Current eating disorder		U = 8675, <i>p</i> = .034		U = 8453, <i>p</i> = .018		U = 8906, <i>p</i> = .066
Yes (n = 58)	11.2 (5.73)		23.2 (4.53)		8.55 (3.35)	
No (n = 361)	9.60 (5.13)		21.3 (5.79)		7.69 (3.49)	
Organic food consumption		$\chi^2(3) = 5.51, p = .138$		$\chi^2(3) = 51.32, p < .001$ A,B>C,D		$\chi^2(3) = 13.71, p = .003$ A,B>D
A. Only organic food (n = 158)	10.5 (5.55)		23.5 (4.68)		8.18 (3.39)	
B. At least once a week (n = 146)	9.78 (5.13)		21.9 (5.60)		8.15 (3.50)	
C. Less than once a week (n = 67)	9.00 (5.01)		19.4 (5.46)		7.26 (3.52)	
D. (almost) Never (n = 51)	8.96 (4.67)		17.5 (6.12)		6.33 (3.23)	
Using diet tracker apps		U = 7611, <i>p</i> = .017		U = 7462, <i>p</i> = .011		U = 7960, <i>p</i> = .052
Yes (n = 52)	11.7 (6.01)		23.1 (5.97)		8.71 (3.71)	
No (n = 367)	9.56 (5.08)		21.4 (5.60)		7.68 (4.43)	
Using weight control apps		U = 14537, <i>p</i> = .790		U = 14621, <i>p</i> = .856		U = 14344, <i>p</i> = .649
Yes (n = 90)	10.3 (5.86)		21.5 (6.30)		8.04 (3.64)	
No (n = 329)	9.69 (5.06)		21.6 (5.49)		7.74 (3.44)	
Using cosmetics and hygiene barcode scanner apps		U = 18781, <i>p</i> = .019		U = 17148, <i>p</i> < .001		U = 20661, <i>p</i> = .422
Yes (n = 234)	10.4 (5.49)		22.5 (5.50)		7.91 (3.48)	
No (n = 185)	9.15 (4.84)		20.5 (5.69)		7.68 (3.48)	

Note. For Kruskal–Wallis tests, only significant results of Dwass-Steel-Critchlow-Fligner post hoc tests were indicated; *SD*: Standard deviation.

Table 4.

*Comparison of the Food Barcode Scanner App Questionnaire (FBSAQ) subscales according to frequency and duration of use of food barcode scanner apps.*

	Pathologic use of apps	Comparisons	Food preoccupation	Comparisons	Exclusion of unhealthy components	Comparisons
	Mean (SD)	$\chi^2$ and post hoc	Mean (SD)	$\chi^2$ and post hoc	Mean (SD)	$\chi^2$ and post hoc
Frequency of use		$\chi^2(3) = 123.5, p < .001$		$\chi^2(3) = 83.7, p < .001$		$\chi^2(3) = 60.4, p < .001$
A. Less than once a month (n = 192)	7.25 (3.15)	B,C,D>A; C,D>B	19.0 (5.61)	B,C,D>A; C,D>B	6.53 (3.18)	B,C,D>A; C>B
B. Several times a month (n = 144)	10.1 (4.63)		23.0 (4.77)		8.26 (3.24)	
C. Several times a week (n = 64)	14.7 (5.80)		24.6 (4.66)		9.72 (3.19)	
D. Almost daily (n = 18)	16.6 (6.13)		26.6 (3.41)		10.7 (3.79)	
Duration of use		$\chi^2(3) = 2.30, p = .513$		$\chi^2(3) = 15.80, p = .001$		$\chi^2(3) = 4.53, p = .210$
A. Less than six months (n = 42)	8.26 (3.36)		19.2 (6.34)	D>A	7.10 (3.18)	
B. Between six months and one year (n = 57)	9.51 (4.75)		20.5 (5.89)		7.12 (3.37)	
C. Between one and two years (n = 149)	9.83 (5.16)		21.5 (5.23)		8.01 (3.52)	
D. More than two years (n = 181)	10.3 (5.74)		22.6 (5.56)		8.04 (3.53)	

Note. Only significant results of Dwass-Steel-Critchlow-Fligner post hoc tests were indicated; SD: Standard deviation.