

The landscape of mobile applications for healthy eating: A systematic review and quality assessment

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Abstract

Background: Mobile applications are increasingly used to foster healthy lifestyles. There is a growing need for clear, standardized guidelines to help users select safe and effective health apps.

Objective: Our study aims to identify mobile apps promoting healthy eating that are worthy of recommendation based on evidence-based practices.

Methods: We conducted a systematic review of apps promoting healthy eating that had already been evaluated by one or more of 28 recognized health app certification bodies. We conducted three rounds of app evaluations using the Quality Evaluation Scoring Tool (QUEST) (first and second rounds). In addition, we used a subjective 0-10 score scale (second and third rounds) in which each reviewer answered the question “how probable is it that you would recommend this app?”. Subsequent discussions were held to resolve scoring discrepancies and to identify the top-quality apps. We also assessed correlations among QUEST scores, app store scores and certification body scores.

Results: Out of 41 applications identified by 5 certification bodies, 19 met inclusion criteria and were examined. Only 16 of these remained accessible for the second round. Eight of these surpassed 20 points (out of a maximum of 28) on the QUEST scale and were evaluated by the 6 experts in the third round. Second Nature, Freshwell, Yazio, Lifesum and MyNetDiary emerged as the leading applications. No correlations among QUEST, app store and certification body scores were found.

Conclusions: Despite numerous evaluations by various certifying bodies, only five apps met the quality standards set by our experts. Our results mark the importance of rigorous, transparent, and standardized app evaluation processes to guide users towards making informed decisions about health apps. Guidelines for app developers towards evidence-based, unbiased, high-quality apps, may be the most feasible path to solve this.

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*Equivalent contribution

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Background: Mobile applications are increasingly used to foster healthy lifestyles. There is a growing need for clear, standardized guidelines to help users select safe and effective health apps.

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towards making informed decisions about health apps. Guidelines for app developers towards evidence-based, unbiased, high-quality apps, may be the most feasible path to solve this.

Key words: Apps (applications); mHealth; nutrition; healthy eating; eHealth; digital health

Introduction

As our world becomes increasingly digital, the utilization of mobile applications (apps) for health-related purposes (health apps) is on the rise (1,2). The World Health Organization's (WHO) Global Observatory of eHealth describes health apps as key components of the broader domain of mobile health (mHealth). The utilization of mobile devices (such as smartphones, patient monitoring tools, personal digital assistants, and other wireless devices) is instrumental to support medical and public health practices. Electronic health (eHealth) encompasses the cost-effective and secure use of information and communication technologies for healthcare and related fields (3). Since the WHO's acknowledgment in 2016 (4), the market has expanded rapidly. There has been an exponential increase in health app availability from 325000 in 2017 (5), to an estimated 255 billion app downloads in 2022 (1,2).

Despite this growth, healthcare professionals lack unified standards for evaluating health app quality, safety, and effectiveness (6). Recent European Union regulations on medical devices, e.g 2017/745 enacted in May 2021, represent significant development. These regulations classify certain health apps as medical devices, necessitating adherence to specific criteria for approval. Supplementary documents from the European Commission (7,8) complement this regulation. The regulation also establishes a medical device database to enhance transparency for

both patients and healthcare providers. However, despite mHealth apps being within the medical device framework and subject to all corresponding laws at European level, there are pending challenges related to user data management. Commercial platforms typically do not furnish reliable information regarding the efficacy or safety of the apps they offer. Health apps should be substantiated by scientific evidence, facilitating their endorsement by healthcare professionals, and enabling end-users to benefit from a validated certification system (9,10).

This study set out to identify and evaluate health apps that promote healthy eating and meet rigorous criteria for quality and scientific evidence, which would qualify them as recommendable to the population.

Material and methods






App identification

An initial exploratory analysis was conducted to identify projects, initiatives and organizations involved in the evaluation of health apps. Most of these resources were catalogued in two documents by the Spanish Ministry of Health (11) and the European project mHealth-Hub (12,13). Both included governmental and non-governmental efforts. From August to December 2021, we searched for health apps that met the following inclusion criteria: aimed at adults (over 18 years old), available in English or Spanish and offering nutritional guidance such as recommendations for dietary changes or meal planning. Apps that solely functioned as food diaries, calorie counters or bar code readers were excluded. The search was limited to Google Play Store (Android system). We examined app descriptions and features to confirm eligibility. The specific search terms used were tailored to each source and included: healthy eating, diet, nutrition, staying

healthy, lifestyle, preventive medicine, weight.

In the absence of established guidelines for health app evaluation, we followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement (14,15), adapted to our research objectives. We reviewed 28 certifying bodies (see supplementary **table 1s**). Only the following 5 contained apps meeting our inclusion criteria (see **table 1** for additional details):

TABLE 1. Summary of certification/assessment bodies that included apps promoting healthy eating.

Name	Logo	Year it started	Country	Reviewers	Evaluation criteria	Public or Private
MyHealthApps		2013 ^a	UK	End-users, associations or caretakers	Scoring system	Private
Healthy Living Apps Guide		2018	Australia	Expert reviewers (at least two on behaviour change /public health)	MARS (functionality) and ABACUS (behavior change)	Public (Government of Victoria)
ORCHA		2018	UK	Experts and reviewers (end-users are considered)	7-steps system	Private (cooperation with NHS)
GGD AppStore		2016	Netherlands	Experts and end-users	4-step, assessment based on questionnaires, including a final evaluation of behaviour change techniques used	Public GGD GHOR
Health Navigator		2017	New Zealand	Experts, clinical reviewers, and end-users	Internal revision by experts, clinical revision, and end-user revision.	Public Ministry of Health

^aClosed 17.5.22

Healthy Living Apps (16) assesses app functionality using the Mobile App Rating Scale (MARS) (17), and behavior change using the App Behavior Change Scale (ABACUS) (18). Each criterion is rated on a scale of 0 to 5 stars, with additional considerations such as app cost and data export capabilities.

Myhealth Apps (19) focuses on user preferences and developer related data. This

resource operates as a catalogue rather than assigning individual scores to apps. It assesses transparency regarding pricing, contact details, geographical location, security measures and more.

ORCHA (Organization for the Review of Care and Health Applications) (20) employs a seven-step evaluation system, comprising three main domains: data, professional guarantee, and usability and accessibility. App functionalities and features are also considered. A maximum score of 100 points is attainable for each domain, with ratings above 65 considered as indication of good quality. Scores between 45 and 65 suggest areas for further investigation and scores below 45 deem the app (or domain) potentially unsafe or ineffective.

GGD Appstore (21) follows an evaluation method considering app availability, pricing, compatibility with different operating systems, provider contact details, promotion of healthy behavior, data management, and goal setting. To enter evaluation, apps must focus on self-care and include at least two methods for behavior change. The apps are also assessed for usability, reliability, privacy, safety and relevance, rating each as good, sufficient, or inadequate. Apps are scored up to a maximum of 5 stars.

Health Navigator (22) is supported by the New Zealand Ministry of Health and provides a library of reliable apps. The evaluation process encompasses app features, functionalities, quality of information and relevance to users. Apps must fulfil specific criteria including evidence-based content, an evaluation of effectiveness, acceptability, and usability, and include a privacy statement. Clinicians with diverse expertise rate the apps from 1 (very poor, not recommended) to a maximum of 5 stars (excellent). End-users also provide feedback. Finally, apps deemed clinically unsafe or potentially harmful are

excluded.

As health apps are frequently updated, a follow-up search was performed in May 2022. By that time, *myhealthapps* was no longer active. From this point on, 3 rounds of app evaluations followed (see **figure 1**).

App assessment

Round 1 (April -July 2022): the content of each of the selected apps was evaluated by pairs from a panel of 3 nutrition experts (ADG MD, specialized in endocrinology and nutrition, GZZ registered dietician and CRR lecturer in nutrition and public health). To facilitate comparison across the apps, we employed the Quality Evaluation Scoring Tool (QUEST) (23), not utilized by any of the evaluating bodies which included the selected apps. QUEST was originally designed to assess health information in digital media and has been tested for reliability and validity. It offers a total score ranging from 0 to 28 points, based on the following criteria: Authorship (0, 1 or 2 points) evaluates the ease of identifying the authors of the content; attribution (0, 3, 6 or 9 points) assesses whether health information is backed by scientific studies; type of study (0, 1 or 2 points, if at least 6 points have been given to *attribution*) evaluates the studies' quality; conflict of interest (0, 3 or 6 points) evaluates if the information promotes purchase of products or services; complementarity (0 or 1 points) evaluates if the information supports the health provider-patient relationship and tone (0, 3 or 6 points) assesses language used as biased, neutral, or acknowledging the limits of knowledge.

The apps were downloaded to Android devices (2 Galaxy Tab A7 Lite SM-T220 running on One UI Core 3.1 and Android 11 and a mobile phone Redmi 9A M2006C3LG MIUI Global 12.0.20 running on MIUI Global 12.0.20 Estable (QCDEUXM) and Android 10QP1A.190711.020). Whenever a premium version was

available, it was tested too. A data extraction template was developed including reviewer ID, date of the evaluation, name of the app, developer, version, device where it was downloaded, score for each item in QUEST and comments. The mean total score was calculated to rank the apps, and inter-reviewer agreement for each QUEST item was measured using weighted kappa coefficients. Concordance for the total score was evaluated using the intra-class correlation coefficient. We also explored potential correlations between the QUEST scores, Google Play Store ratings and the scores from each assessment body, (all three, non-normally distributed quantitative continuous variables), using Spearman's coefficients. For these procedures we used R-software (24): RStudio version 1.3.1056, with the *vcd* library. Following the analysis, discrepancies in the evaluation of QUEST items were discussed to identify their underlying causes.

Round 2 (Sep 2023): an expanded panel of 4 additional reviewers (ATC and MLAM, PhD Psychologists, experts in behavior change; ITG professor in epidemiology, expert in health promotion and GS, PhD and registered dietitian, expert in prevention through diet) re-evaluated the apps (4-5 each), using the same methodology, but limiting the time spent in the evaluation to a maximum of 45 minutes per app. Apps with a score average over 20 points (out of a maximum of 28) either in the initial evaluation or in the update, were selected for further analysis. Although no given cut-off is recommended for the tool, this threshold was chosen to ensure the inclusion of apps that meet a fair-to-high standard. All evaluators were asked to subjectively score [0-10 points] their assigned apps answering the question: *how probable is it that you would recommend this app?* Apps with a difference of 3 or more points in the initial and updated QUEST scores were discussed within the same reviewer pair (one of the reviewers involved in the

first round and the new expert involved in the second round), to solve or explain this discrepancy. This process was documented, summarized, and then discussed during a meeting involving all the authors, including AMW (MD PhD, specialist in endocrinology, nutrition and diabetes). The meeting was recorded, transcribed, and summarized in a document which was shared with the participants for feedback.

Round 3 (Jan 2024): the last version of the selected apps was downloaded and assessed by 6 experts (GZZ, ADG, ATC, MLAM, ITG and GS), who had participated in the previous rounds. The subjective score was given again, this time assigning up to 4 points for content quality (this aspect being the most relevant for our research) , 3 for usability and 3 for promoting behavior change. Further discussion among all the authors led to the final ranking and the selection of the top 5 apps.




















Results

Among the 28 certification bodies identified, 14 catalogued a total of 557 apps across various categories, encompassing terms like “healthy eating”, “nutrition”, “diet”, “healthy practices”, “lifestyle”, and more. However, only 5 of these initiatives contained apps that met our inclusion criteria. These certifying bodies used a variety of criteria in their evaluation processes, both in terms of the elements assessed and the tools employed. Nevertheless, there was a significant overlap in the factors considered key for determining app quality including functionality, usability, engagement, aesthetics, privacy, data protection and effectiveness in promoting behavior change.

A total of 41 apps met the inclusion criteria. After eliminating duplicates, 30 apps remained, of which 11 met exclusion criteria (see **figure 2**).

The characteristics of the final 19 apps are summarized (see **table 2**). Five of these were included in two or more of the certification bodies: *MyfitnessPal*, *FatSecret*, *MyNetDiary*, *Noom* and *8fit Workout & Meal Planner* (for additional details see **supplementary table 2**). Notably, only the apps included in ORCHA had undergone formal evaluation of their content.

TABLE 2: Main Features of the 19 selected and evaluated health apps.

Nº	Name Developer	Logo	Description
1	Noom Noom Inc.		Uses behaviour change psychology to promote healthier habits, weight loss, and health goals. It can track meals and link to a pedometer.
2	YAZIO YAZIO		It is a food diary and calorie counter that also offers diets and recipes, including vegan, vegetarian, and intermittent fasting options.
3	FatSecret FatSecret		It is a food diary and calorie counter. It allows to scan products barcodes, tracking weight, and keeping a record of meals and consumed food photos.
4	MyNetDiary MyNetDiary Inc.		It is a food log and calorie counter, provides diets and recipes. It has a food database and a barcode scanner. It also offers motivational messages to achieve nutritional goals.
5	DietBet WayBetter Inc.		It aims to help the user achieve healthy weight loss and maintain motivation. It offers a support community, customer service and expert-led games (coaches, nutritionists, etc.).
6	MyfitnessPal MyFitnessPal Inc.		It offers recipes, a meal planner, a calorie counter, and workout plans. It allows tracking progress and setting macronutrient goals.
7	MyPlate* LIVESTRONG		It allows tracking calories and exercises. Tracks the users' progress based on calorie and nutrient goals. Provides motivation through support groups.
8	LIFESUM Lifesum		It functions as a food diary and offers various types of diets and recipes. It also allows tracking exercise and water intake. Allows setting weight goals and health data.
9	8fit Workout & Meal Planner Urbanite Inc.		It offers workout routines in different categories (boxing, yoga, HIIT, etc.) along with meal plans.
10	Freeletics nutrition Freeletics GmbH		Acts as a nutrition coach to help the user achieve dietary goals. Guides the user towards healthy eating, recipes, etc. Helps adapt nutrition to personal goals.
11	GetFit-Daily Planner* Meal App Prodakshn;OOO		Provides daily and weekly meal plans to lose, maintain, or gain weight based on users' goals. Calculates nutrients, calories, water intake, body mass index, etc. Includes reminders.
12	HealthifyMe HealthifyMe		Can act as a calorie counter, provides weight loss and exercise plans, guides sleep hygiene, etc.
13	Eat this Much-Meal Planner Eat This Much Inc.		Meal planner based on dietary preferences, budget, etc. Can be configured for different types of diets.
14	LIFE Extend* LifeOmic		Marketed as a precision health mobile app to help improve users' health using 5 pillars of health.
15	Fastic Fasting Ap Fastic GmbH		App promoting intermittent fasting with different levels of intensity (gentle, moderate, intense).
16	Second Nature Second Nature		It provides a lifestyle change program that helps lose weight and develop healthy habits. Nutritionists guide the user throughout the program. Includes a support group.
17	Uplyfe-Precision Nutrition* Uplyfe AG		Marketed as a customized nutrition and lifestyle change app guided program based on scientific findings. Provides personalized nutrition plans, activities, and symptom tracking.
18	Freshwell Freshwell		Their healthcare personnel promote a low-carb diet. They provide Informative weekly modules, meal planner, etc.
19	Contador de calorías Virtuagym		It provides a personalized nutrition plan according to the users' lifestyle and goals.

*No longer available

Per definition, all apps included nutritional interventions, but most also combined

different strategies or features, making their categorization challenging. Fourteen apps included weight control or tracking (labelled as 1-6, 8, 11, 12, 14, 16-19 in table 2), twelve allowed for calorie counting (labelled 1-4, 6-8, 11-13,17,19), while thirteen facilitated the recording of physical activity (labelled 1-4, 6-9, 14-17, 19). Twelve apps (labelled 1-8,10,11,16,18) incorporated behavior change techniques, such as motivational feedback, health education promotion and goal setting.

Table 3 presents the scores given to each App by the reviewers during the three rounds of assessment, by the certification bodies, as well as the score on a commercial app store.

TABLE 3: Scores of the different evaluation tools and rounds of revision for each app.

APP NAME First version evaluated and date of update of that version (year launched)	Round 1: QUEST	Round 2: QUEST	Round 2: subjective	Round 3: subjective	2022Play Store (Stars)	ORCHA	Health Navigator	GGD	healthylivingapps
Maximum score	28	28	10	10	5	100	5	5	5
Nº evaluators (total/per app)	3/2	4/1	6/6	6/6	-	-	-	-	-
<i>Apps that went through all evaluation rounds</i>									
Freshwell 1.1.1, 25/10/21 (2021)	21.5	28	7.2	6.9	5	68	-	-	-
Yazio 7.10.8, 08/08/22 (2014)	21.5	18	8.2	7.4	4.6	-	-	4.1	-

Lifesum 11.0.0, 30/06/22 (2011)	20.5	14	7.2	6.8	4.5	-	-	-	-
MyNetDiary 8.1.1, 12/08/22 (2010)	18.5	22	6.2	6.8	4.6	79	-	-	2.5
Second Nature 6.10.2, 11/08/22 (2016)	12	28	8	8.5	4.6	84	-	-	-
Freeletics Nutrition 1.27.12, 27/01/20 (2016)	7.5	21	6.7	5.5	3.8	-	-	-	2.5
<i>Apps included in first two rounds only</i>									
HealthifyMe 18.7.1, 01/08/22 (2013)	21.5	13	2.5	-	4.4	-	-	-	2
LifeExtend^a 5.8.3, 09/08/22 (2019)	20.5	24	5.5	-	4.1	74	-	-	-
Noom 10.28.0, 17/08/22 (2011)	17.5	12	-	-	4.2	80	5	-	-
Fastic Fasting App 1.105.0, 16/08/22(2019)	14	11	-	-	4.7	70	-	-	-
Fatsecret 9.12.5.2, 25/05/22 (2007)	11	10	-	-	4.7	-	4	4	-
Eat This Much 2.0.12, 12/08/22 (2016)	11	13	-	-	4.4	-	-	-	2
8fit Workout&MealPlanner 22.4.0, 09/05/22 (2014)	10	14	-	-	4.3	75	-	-	2.5
DietBet 18.0.0, 04/08/22 (2014)	8.5	6	-	-	4.7	-	-	-	2.5
MyFitnessPal 22.15.0, 03/08/22 (2010)	6.5	5	-	-	4.4	47	3	3	-
Contador de calorías 3.7.3, 28/04/22 (2014)	6	6	-	-	4.5	-	-	4.5	-
<i>Apps included in first round only</i>									
GetFit^b 1.3.4, 23/04/23 (2020)	16.5	-	-	-	1	-	-	-	2.5
MyPlate^c 3.5.3(63), 30/09/21 (2015)	14	-	-	-	4.6	-	-	-	-
Uplyfe-Precision Nutrition^d 1.8.1, 21/09/21 (2020)	13.5	-	-	-	4.2	70	-	-	-

^{a, b, c, d}. Apps that became unavailable during the evaluation process.

Evaluation - Round 1: Table 2s (see supplementary material) displays the score of each QUEST item in the first round of evaluations, categorized by reviewer, with apps ranked according to their mean total score. We explored potential correlations between the QUEST scores, Google Play Store ratings, and the scores of each certification body and found no significant correlations among any combination (data not shown). Agreement reached between reviewers was rather low, with most kappa values below 0.6 and inter correlation coefficient between 0.50 and 0.67 (see table 3s, supplementary material). The main reasons for discrepancy were attributed to the difficulty in finding the information needed to complete the QUEST scale.

Evaluation - Round 2: Four additional experts were asked to update the app review on an Android device and were given a maximum of 45 minutes per app to

find the information. At the time of this evaluation, 3 apps [MyPlate, GetFit and Uplyfe-Precision Nutrition] were no longer available and the remaining 16 were scored (see **table 3**). One of the reviewers used an IOS device (Iphone), due to unavailable Android devices. The 7 apps which had received a score above 20 (out of a maximum of 28) either in the first evaluation or in the update were selected for further assessment.

Challenges were encountered assessing the items “authorship”, “attribution” and “tone”. Some apps (particularly *Lifesum*, *Freeletics*, *Eat this much*, *Life extend* and *Second Nature*) lacked clear indications regarding authors and sources, necessitating external web searches to retrieve this data, and even then, it took a considerable time. Additionally, reviewers noted that the “attribution” item could be easily altered to achieve higher scores; e.g. referencing a source, even if it was a low-quality source or irrelevant to the app’s health information, could lead to a high rating as long as it was a highly scored type of study. Subjectivity was also a significant factor in evaluating the “tone” *item*, leading to disparities in scores. Finally, some of the discrepancies were explained by the differences in app versions (e.g. *Freeletics Nut*, *Fresh Well* and *Second Nature* improved considerably between review rounds, coinciding with version changes, whereas the opposite was true for *HealthifyMe*). In the case of *HealthifyMe*, this (and the low subjective score) led to its exclusion from the third round despite scoring above 20 points in the first round. Discussion about the subjective scores led to a more structured scoring procedure in the third round.

Evaluation – Round 3: All experts participating in the previous rounds of evaluation, except for one who was no longer available for the task, took part in this round. At the time of this evaluation (early 2024), *LifeExtend* was not available,

so only 6 apps were included in the third round. Discrepancies in the scores were discussed among researchers.

Subjective scores were also given to the selected apps by all 6 reviewers (see **table 3**). The scores were discussed in a joint meeting, which led to the selection of the top 5 apps: *Second Nature*, *Freshwell*, *Yazio*, *Lifesum* and *MyNetDiary*. The scores given by each evaluator are included in the supplementary material.

Second Nature was consistently the most highly scored app and is also endorsed by the National Health Service of the UK. Its present version includes clear references to the evidence supporting its contents. Usability is good and improved by the inclusion of interactive content such as videos with advice and encouragement in the update. There is a wide variety of dietary patterns to choose among and recipes with visual backup are provided. Furthermore, most of the features are free to use. On the other hand, food registering is rather cumbersome, and the tone of the recommendations could be more cautious.

Freshwell was developed by two British general practitioners and is used by the National Health Service in the UK. Usability is good with pictures, recipes, and explanations. Long-term goals are included, promoting behavior change. A classification of foods is included, based on the type of dietary pattern which is promoted (low carb). Study references are provided to support this recommendation, and a disclaimer is provided stating that the app provides educational content and is not to be considered medical advice. People with chronic conditions are advised to ask their healthcare provider. Other health-promoting pieces of advice include reducing sugar intake, snacks, and alcohol. The subjective score penalized the low carb type of dietary pattern on which the app is based, since reviewers considered that there is not sufficient evidence to promote

it to the general public as the “default” dietary pattern (25).

Yazio has high usability due to likable aesthetics, ease of use, accessibility and the challenges included in the app. The latter, which promote behavior change, can be chosen by the user from a list including quitting chocolate, sugar, sweets, fast food, etc. The app includes information about healthy eating which is supported by scientific evidence and the standard recommended diet is Mediterranean style. However, it also included dietary patterns with less scientific evidence of benefit, such as intermittent fasting or the keto diet. In fact, intermittent fasting is a very prominent feature of this app, including challenges on how long you can fast for. A disclaimer recommends not using this pattern in the long term and seeing a physician if that is the intention of the user.

Lifesum has a visually pleasant interface and agile and intuitive navigation, which lead to good user experience. Different objectives can be set, and the app includes easy and advanced recipes which help with organization and motivation for healthier eating, although all this is only available for the premium version. It includes a score for easy comparison and progress tracking, but the criteria for the score are not transparent. Studies supporting the contents were not easily found and were not there for all the recommendations. Once again, the latter included intermittent fasting and keto diets. Minor bugs were identified, in the form of non-functioning links.

MyNetDiary offers an attractive design, easy navigation, and a variety of resources to engage users. It provides information on different types of diets and highlights their key aspects. Examples of recipes for each type of diet are included with detailed descriptions. The content is supported by a trained specialist in the nutritional management of diabetes and other health problems. A diary function to

track daily food intake in included and data can be entered via text, audio, or barcode scanning. The premium version offers daily advice and feedback. Users can also access a nutrition blog written by the same specialist behind the app. Professionals can subscribe, to connect with users interested in weight loss.

Discussion

In this paper, we highlight the importance of assessing the quality of apps promoting a healthy diet before recommending them to end-users. Despite their previous assessment by dedicated certification bodies, only 5 apps (out of 19) promoting a healthy diet were deemed recommendable by a panel of experts in nutrition. The selection was based on a comprehensive assessment of the quality of their contents (based on QUEST), as well as their usability and behavior change techniques.

Health apps have emerged as promising tools to promote behavior change, encouraging healthier lifestyles, due to their widespread accessibility, user-friendliness, and cost-effectiveness (26–28). They offer significant potential for health promotion and advancement of public health measures. However, the app market's diversity and lack of a systematic evaluation processes leaves consumers with limited tools to judge which apps are effective, safe, and suited to their needs. Descriptions and ratings found in app stores are the most accessible and direct sources of information for users. However, they are heavily influenced by popularity and sponsored content rather than evidence-based and clinically validated criteria and guidelines (29). This highlights the need for alternative methods to help users identify safe and effective health apps.

To address this issue, several national and international actions have attempted to

assess health app quality and safety (16,19–22). Our investigation identified several initiatives dedicated to the evaluation of health apps. While each of these uses distinct criteria for app evaluation, they generally emphasize similar key factors including data security, privacy, ease of use, accessibility, usability, support for user-healthcare professional communication, personalization options, and capacity to induce behavior change. In a recent review, the importance of adherence to scientific evidence, as well as additional features such as gamification and co-creation of the app with health professionals and users were supported (30). Although a multitude of tools, scores, and tests have been proposed to evaluate different aspects of app quality, as of today, one single robust procedure or set of criteria does not exist (31–33). Some national and international efforts for the standardization of health app evaluation have been developed (34–36), but still have some limitations. Additionally, despite several certifying bodies' efforts to evaluate health apps, all the certification bodies reviewed in this study cautioned that they cannot guarantee the precision, quality, trustworthiness, and effectiveness of the health apps they assess, increasing uncertainty for the users. Thus, currently a high rating from either the evaluating bodies or the app stores does not ensure the safety or utility of any given health app.

Acknowledging these challenges, our study sought to evaluate nutrition-focused health apps using a tool aimed at the health information within the app, assuming that evidence-based and unbiased health information would support their safety and effectiveness. We selected QUEST to assesses this, since it was specifically designed to evaluate health information and incorporates items such as *attribution* or *study type* to evaluate the quality of information sources. Additionally, it assesses items such as *conflict of interest* and *tone* to evaluate how information is presented

to the user, where any sort of advertising is penalized. We found no significant correlations among the Google Play Store scores for the apps, the QUEST total mean score or any of the initiatives' certifier scores. This is probably because they assess different dimensions. QUEST focuses on the quality of the content, but does not evaluate usability, engagement or behavior change techniques. These are all known factors that influence the perceived quality of an app (37). Such factors may influence the app store ratings, and many are directly evaluated by the certifying bodies, but are overlooked by QUEST. On the other hand, Google play store scores are based on user opinions, which can be influenced by all these factors, but also by popularity, endorsement by influencers, aesthetics, or alignment with their own nutritional preconceptions, which may not be backed by scientific evidence.

Furthermore, it is important to acknowledge that apps are dynamic and subject to constant updates. While the latter can be beneficial if they enhance the quality of app contents, they also pose a challenge for app evaluation (38). Thus, continuous reassessments would be necessary to account for the changes. Access to older app versions may not always be possible, and certain apps may become completely inaccessible over time. Imposing regulations that account for this could potentially slow down the fast development and innovation that characterizes this field. However, it could also mitigate the health risks posed to users who download untested and scientifically unsupported health apps. We consider that any app marketed as a health app should be subject to special scrutiny, particularly regarding collection of sensitive data and potential for harmful effects on users. Previously proposed improvements include establishing national lists of tested and trusted health apps, creating a catalogue of health apps accessible to patients only if prescribed by professionals and guidelines for app developers towards

evidence-based, unbiased, high-quality apps, with wider assessment requirements for higher-risk tools (13,34,38–41).

Our work has several strengths that contribute to the field of health app evaluation. Firstly, the adoption of the QUEST tool signifies a rigorous approach towards assessing the quality of health information within apps, addressing critical components such as attribution, authorship, and conflict of interest. We found the QUEST tool to be beneficial in the evaluation of health information. Its specific design ensures focused analysis of relevant content, enhancing the reliability of the findings. This systematic assessment of the contents was complemented by a subjective evaluation by the panel, of usability and behavior change techniques. Additionally, the study's methodological approach, involving multiple, independent reviewers and the evaluation of a diverse range of apps, strengthens the validity and comprehensiveness of the results. Finally, the study's alignment with existing literature and national and international certification/assessment bodies highlights its relevance and potential impact on improving health app quality and user safety.

We acknowledge that the study also has some limitations. The small sample size of apps reviewed and its focus on nutrition-related interventions may limit the generalizability of our results, since they present an incomplete picture of the overall quality and safety of available health apps. Another limitation is the potential bias introduced by the subjective nature of the review process, despite efforts to mitigate it through the involvement of multiple reviewers and iterative review rounds. Also, some aspects of app quality are overlooked by the QUEST assessment tool (such as usability, engagement, and capacity to induce positive behaviour changes). Moreover, some of its items are, to some extent, subjective

(such as “tone”) or can be easily altered to obtain undeserved high scores (“attribution”). Therefore, it is not a comprehensive enough tool to judge app quality on its own. The dynamic nature of apps, with frequent updates and changes, poses a challenge for maintaining up-to-date evaluations, indicating a need for continuous reassessment to ensure accuracy. Lastly, the decision to exclude apps that solely function as food diaries and calorie-counters may be controversial. We chose apps with nutritional interventions, offering meal plans and recipes to analyse the type of nutritional pattern suggested by the app, something that we considered crucial for our study. Nevertheless, we acknowledge that food diaries and calorie-counting could also help the user be more aware of their eating habits and induce a change in their behavior despite not offering any other specific nutritional advice and therefore they could be considered a type of intervention.

In conclusion, despite previous evaluations by various certifying bodies, only five out of 19 apps promoting healthy eating met the quality standards set by our experts. Our study calls for enhanced scrutiny and regulatory measures to ensure that health apps, particularly those focused on nutrition and health promotion, meet rigorous standards of accuracy, reliability, and user safety. Guidelines for app developers towards evidence-based, unbiased, high-quality apps, may be the most feasible path out of this jungle.

Declarations

- **Ethics approval and consent to participate:** Given the nature of our work, no ethic committee approval or informed consents to participate were needed.
- **Consent for publication:** All authors declare their consent for publication.

- **Availability of data and materials:** All relevant data is available for direct review within the article.
- **Competing interests:** All authors declare not to have any competing interests.
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- **Authors' contribution:** AD, GZ and AW designed the study. AD and GZ performed the search and first round of assessments. IT, GS, AT and MLA performed the second round of assessments. All authors participated in the discussions and final ratings of the apps. AD y GZ summarized and analyzed the results. AD and GZ drafted the manuscript. All authors participated in the revision of the paper and approved the final version.
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- **Declaration of Generative AI and AI-assisted technologies in the writing process:** During the preparation of this work the author (s) have not used any artificial intelligence tools /services at any time. The authors are responsible for the entire content of this publication.

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