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NUTRITION APPS ON FOCUS: A QUALITATIVE ASSESSMENT[i]

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Abstract:
The quality of nutrition apps can be evaluated by applying scientifically validated instruments. The objective of this study was to perform an in-depth quality-analysis of nutrition-related apps and to identify communalities and limitations of different assessment tools. Based on a keyword search for "nutrition" within the German Google Play Store, ten nutrition-related apps were selected and evaluated for quality using the App Quality Evaluation (AQEL), Mobile App Rating Scale (MARS) and "ENLIGHT" tools. The analyses highlighted discrepancies in app qualities regarding performance, credibility, security and user benefits. Given the three evaluation tools, each of which focuses on different aspects of quality, they cover a broad spectrum of quality criteria is covered. However, there are also overlaps in the evaluation categories function and functionality, credibility and evidence-base. Due to distinct scoring systems within the tools, overlapping categories were not interchangeable and aggravated a comprehensive app quality rating. Our findings indicate that AQEL, MARS and ENLIGHT, on a stand-alone basis, are suitable tools to assess individual aspects of quality for nutrition apps, without being exhaustive. A series of additional important quality aspects was identified, which can make an important contribution towards the development of an overarching quality assessment tool specific for nutrition apps.

Keywords: nutrition apps, quality testing, evaluation tools

[i] ERNÄHRUNGS-APPS IM FOKUS: EINE QUALITÄTSBEWERTUNG

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Abstract:
Die Qualität von Ernährungs-Apps kann durch die Anwendung wissenschaftlich validierter Instrumente evaluiert werden. Ziel dieser Studie war es, eine detaillierte Qualitätsanalyse ernährungsbezogener Applikationen durchzuführen und Gemeinsamkeiten und Limitationen verschiedener Bewertungstools zu identifizieren. Basierend auf einer Schlagwortsuche zu „nutrition" innerhalb des deutschen Google Play Stores wurden zehn ernährungsbezogene Apps ausgewählt und hinsichtlich ihrer Qualität bewertet. Hierzu wurden die App Quality Evaluation (AQEL), Mobile App Rating Scale (MARS) und "ENLIGHT" Instrumente eingesetzt. Die Analyse verdeutlicht die Diskrepanzen bezüglich der App Qualität hinsichtlich Performanz, Glaubwürdigkeit, Sicherheit und Nutzervorteile. Die hierzu verwendeten Evaluationsinstrumente fokussieren sich auf unterschiedliche Qualitätsaspekte und decken ein breites Spektrum an Qualitätskriterien ab. Überschneidungen existieren hinsichtlich der Evaluationskategorien Funktion und Funktionalität, Glaubwürdigkeit und Evidenzbasierung. Aufgrund der abweichenden Bewertungssysteme ist es nicht möglich gleiche Kategorien auszutauschen, welches eine allumfassende App-Qualitätsbewertung erschwert. Unsere Ergebnisse weisen darauf hin, dass AQEL, MARS und ENLIGHT individuell betrachtet, geeignete Instrumente zum Erfassen einzelner Qualitätsaspekte von Ernährungs-Apps darstellen, jedoch nicht allumfassend sind. Ergänzend wurden weitere wichtige Qualitätsaspekte identifiziert, die einen bedeutsamen Beitrag zur Entwicklung eines allumfassenden Qualitätsinstruments zur Bewertung von Ernährungs-Apps liefern könnten.

Keywords: Ernährungs-Apps, Qualitätsbewertung, Evaluationsinstrumente

1. Introduction

In the current age of progressive digitalization, electronic communication media have become an integral part of our society. According to the latest information,[17] around 67% of the world's population owns a mobile device (mobile phone, tablet or Internet of Things device). Forecasts also predict that mobile internet will penetrate 61% of the world's population by 2025.[17] Current estimates indicate that adolescents in Germany spend an average of three to four hours a day on digital media,[17,23] and preferentially use smartphones to go online.[29] In terms of digitally spent time, the use of online applications, or so-called apps, is at the top of the ranking,[9] and the use of nutritional and health apps in particular is currently booming. Measured against a share of around three million apps available worldwide in the Google Play App-Store in mid-2019,[19] roughly 98.000 apps could be attributed to the categories "health and fitness" and "medicine", including nutrition apps. Regarding this enormous variety of smartphone apps in the nutrition sector, it is becoming increasingly difficult for users to identify high quality and evidence-based apps.

Experience shows that app users select applications largely based on perceived design quality and user-friendliness,[3] and tend to rely on the well-known 5-star rating

system, which is primarily based on subjective assessments by other users and is not considered a reliable quality indicator from a scientific point of view.[28] Unlike medical devices, which are subject to legal certification prior to marketing in the European Union,[10] most nutrition apps lack validation. Their contents are largely non-transparent and their usage may even be associated with health risks. Despite major efforts to introduce mandatory certification specifically for electronic health (eHealth) applications, there is still a lack of quality assurance regulations for nutrition applications. In the United States,[14] UK[25,26] and Germany,[8,35] various app testing platforms were established, some of which have since been ceased. Few of these platforms use validated tools from experts for their app quality tests and have developed their own quality labels as a symbol of trustworthiness.[20]

In view of the fact that some professional associations in Germany have also developed their own quality seal for healthcare apps,[5,7] the situation is becoming increasingly confusing for app users. Even after the entry into force of the new Digital Supply Act in Germany, which allows the prescription of health apps after prior examination by the Federal Institute for Drugs and Medical Devices, no standardized approaches to judge the apps exist. Based on this, important quality aspects for nutrition apps are highlighted and discussed from a scientific perspective. In this study, selected nutrition apps were illuminated at a qualitative level using various scientifically validated assessment tools aiming at identifying important quality aspects to be considered for a comprehensive quality assessment of nutrition apps, thus contributing to a more precise quality review. Complementary, the turnover rate of nutrition apps in the German Google Play Store was examined more closely over the course of a year between January 2019 and January 2020.

2. Material and Methods

2.1 App screening

A search within the German Google Play Store was conducted on January 30, 2020 using the term “nutrition” in order to identify relevant nutrition-related apps. The listed 250 mobile apps were exported and ranked by their 1.) number of installs, 2.) 5-star user ratings in descending order and 3.) number of reviews. The inclusion criteria focused on the general population rather than specific target groups (e.g. pregnant women or specific medical conditions). Ten apps were selected exemplarily for a comprehensive quality assessment. For all test cases, only the basic version, available free of charge, was chosen for further analysis. To cover the broad spectrum of nutrition apps, four apps with “high user ratings” (installs >1.000.000; reviews >4-star rating), four apps with “medium user ratings” (installs >50.000; reviews 2-4-star rating) and two apps with “low user ratings” (installs <50.000; reviews <3-star rating) were selected for an in-depth quality check.

2.2 App quality rating

All analyses were performed using three different validated and previously published quality assessment tools 1.) the App Quality Evaluation (AQEL) instrument, a checklist

to evaluate an app's educational quality and technical functionality,[13] 2.) the Mobile App Rating Scale (MARS), a questionnaire to classify the quality of mobile health apps[30] and 3.) the ENLIGHT score, a comprehensive quality and therapeutic potential evaluation tool for mobile and web-based eHealth interventions.[4] The AQEL and MARS checklists were used to the full extent, while AQEL assessment was conducted using an online survey (https://illinoisaces.co1.qualtrics.com/jfe/form/SV_3gY2i3sP113ehAV) coded in Qualtrics (version 2017, Provo, UT). For the ENLIGHT score, independent checklists focusing on general app quality (Credibility, Privacy Explanation, Basic Security) were extracted, subscales related to therapeutic aspects were neglected. Quality assessments were carried out by two independent nutrition experts following familiarization and thorough app testing.

The apps were also checked for the validity of their nutritional information (based on the "Big 5", i.e. content of energy, fat, carbohydrates, protein, and salt/sodium). The nutrient content of individual food items was compared against the German Nutrient Database (Bundeslebensmittelschlüssel; *BLS*), and nutrient intake recommendations were contrasted with the guidelines of the German Nutrition Society (DGE). In addition, a more in-depth analysis regarding the provision of nutrition apps in the German Google Play Store was carried out on January 10, 2019 and on January 30, 2020 using the keyword "nutrition". The hits for both years were ranked according to the number of app installations and star ratings of app users. Then the ranks of the top 50 apps in 2019 were compared with their ranks in 2020. Based on this data, changes in the rank number of individual nutrition apps and the overall fluctuation rate were examined in more detail.

3. Results

3.1 App selection and specifications

The search for nutrition apps in the German Google Play Store in January 2020 returned 250 entries. According to the selection criteria specified above, the following nutrition apps were selected for a comparative quality assessment: 1.) *Samsung Health*, 2.) *Calorie Counter - MyFitnessPal*, 3.) *Calorie Counter by FatSecret*, 4.) *Calorie Counter by Lose It!*, 5.) *Ultimate Workout Nutrition*, 6.) *Nutrition Facts*, 7.) *Nutrition Tracker*, 8.) *My Diet - Vitamins Tracker*, 9.) *Recipe IQ: Nutrition Calculator*, 10.) *Vegetarian and Vegan Recipes*. **Table 1** provides an overview of general app information on developer, country of manufacture, latest update, tested version, and corresponding average user evaluation based on a five stars rating scale. The overview shows that the considered apps originate from a broad variety of countries and even several continents. In terms of timeliness, six out of the ten apps were updated within the last six months, whereas the apps *Vegetarian and Vegan Recipes*, *Nutrition Facts*, *Nutrition Tracker* and *My Diet - Vitamins Tracker* were last updated more than a year ago. The subjective quality rating of app users ranged from 2.7 stars for *Nutrition Tracker* up to 4.7 stars for the *Calorie Counter by FatSecret*.

3.2 Quality assessment using the AQEL tool

The quantitative evaluation of selected apps regarding their behavior change potential, support of knowledge acquisition, skill development, function and purpose was carried out with the AQEL online questionnaire. The results are summarized in **Table 2**. Overall, it became apparent that the majority of the apps pursue a clear objective and are either designed for a general audience or for specific age groups. From a functional perspective, deficits were identified for *Recipe IQ: Nutrition Calculator* and *Vegetarian and Vegan Recipes* in the app function sub-categories design (aesthetics), navigation behavior and speed of loading (not listed in Table 2). Apart from *Samsung Health*, *Calorie Counter by Lose It!*, and *Vegetarian and Vegan Recipes*, none of the tested apps scored better than 7.3 in the educational sections of behavior change potential and support of knowledge acquisition. Except for the *Vegetarian and Vegan Recipes* app, very low scores were consistently achieved in the skills development category, involving the acquisition of procedural knowledge. Overall, eight out of ten apps reviewed satisfied the users` expectations moderately to well. With regard to its supportive value for specific nutritional issues, only *Ultimate Workout Nutrition* achieved a high rating. In contrast to *Samsung Health*, *Nutrition Tracker* and *Vegetarian and Vegan Recipes*, *Nutrition Facts* turned out to be rather less suitable for providing nutritional education.

3.3 Quality assessment using the MARS tool

The average MARS rating was highest for *Samsung Health* at 4.5 out of 5 (**Table 3**). The app stood out clearly in almost each of the four quality dimensions of engagement, functionality, aesthetics and information content. Regarding the engagement score, the app exhibited clear strengths related to its entertaining information transfer, its personalization options and extensive user interactivity. In terms of functionality, the app scored high for its simple and intuitive operation and gestural design. Also, in the category aesthetics, which focuses on the graphical design and visual appeal, *Samsung Health* achieved the maximum score of 5.0. From a scientific point of view, the app's information content, in qualitative and quantitative respect, and its credibility were considered as "good" (achieving 4 out of 5 points). The calorie counter apps *MyFitnessPal* and *Lose It!* as well as *Nutrition Tracker* scored "good" in the average quality ranking. The four apps *Calorie Counter by FatSecret*, *Ultimate Workout Nutrition*, *Nutrition Facts*, *My Diet - Vitamins Tracker*, and *Vegetarian and Vegan Recipes* achieved an acceptable average rating score. The MARS analysis showed that qualitative differences among all apps evaluated were evenly distributed across the four quality dimensions and not specifically related to certain ones. The lowest MARS average score of 2.4, equating to poor, resulted for *Recipe IQ*: *Nutrition Calculator*. This app showed clear deficits in all of the MARS criteria examined, resulting for example from the non-entertaining character of the app, low personalization options, missing logical connections between screens and difficult navigation, or absence of proof of origin/references for output information.

3.4 Quality assessment using the ENLIGHT tool

The qualitative review of the nutrition apps according to the ENLIGHT criteria focusing on credibility of app manufacturers, ensuring data protection and system security,[4] showed significant differences (**Table 4**). The credibility check included aspects of whether the app originates from a trustworthy source, is updated regularly, was developed with the support of advisory experts, bears a certified quality label, offers adequate market penetration or has been tested in empirical scientific studies. In the quality category credibility, four out of ten apps obtained the rating "very good" (at least 6 out of 10 points) or even "excellent" (at least 8 out of 10 points), three apps were classified as "fair" (3 or 4 points) and three apps were rated as "poor" (2 points). *Samsung Health* and *Calorie Counter - MyFitnessPal* proved to be extremely trustworthy in terms of precautionary measures taken to protect the privacy of its users. This included, for example, that users were comprehensively informed within the app's Privacy Policy about the type of personal information stored at an early stage, the guarantee for security of data storage, and the purpose of personal data processing. For *Vegetarian and Vegan Recipes*, serious gaps in protecting sensitive user data were identified, while for *My Diet - Vitamins Tracker*, no privacy policy was available at the time of testing. Examination of program security regarding the password-protection of user data, the encryption of communication between servers and clients, the documentation of data exposure and logon activities, proved to be highest for the calorie counters of *MyFitnessPal*, and *Lose It!*. Considerable safety deficiencies were recorded for *Nutrition Facts*, *Nutrition Tracker* and *My Diet - Vitamins Tracker*. All the other apps examined ranged in the medium security level.

3.5 Identification of extra quality features

On closer examination of the nutrition apps, further relevant quality aspects were identified, which are not covered by the previously applied tools (cf. **Table 5**). Firstly, most of the applications showed a high advertising presence, including proprietary or cookie-based promotional offers, some of which were of limited seriousness in the thematic context (e.g. amazon shopping advertisement, videos for dental health, advertisements for cars or trading goods). Secondly, *Nutrition Facts* provided links to external websites such as Wikipedia to provide users with supporting information on micro- and macronutrients. Scientific evidence suggests that Wikipedia often does not provide comprehensive information on nutritional content.[31] *Samsung Health* also linked to external websites of health and lifestyle magazines on the subject of nutrition (e.g. Fit for Fun, Men´s Health Deutschland), but in contrast to *Nutrition Facts*, app users were expressly informed in advance that no liability is given for completeness and accuracy of third-party content. Thirdly, just S*amsung Health*, *Nutrition Tracker* and *My Diet - Vitamins Tracker* provided information on the type of food databases and reference values integrated in the apps to generate nutrient intake recommendations. In the case of *Samsung Health*, the app's nutrient intake recommendations were based on the Harris-Benedict equation for estimating the basal metabolic rate,[27] the reference values for nutrient intake from the US Food and Nutrition Board from 2005,[21] and the reference

values for nutrient intake for Koreans were derived from the Korean Nutrition Society of 2010.[32] *Nutrition Tracker* made use of the food composition table Ciqual from 2012,[1] a reference database on the nutritional composition of foods maintained by the French Observatory of Food Quality, and the USDA National Nutrient Database of the U.S. Department of Agriculture.[33] Dietary reference intakes proposed by *My Diet - Vitamins Tracker* were, as with *Samsung Health*, based on the guidelines of the US Institute of Medicine´s Food and Nutrition Board.[21] Fourth, based on the descriptions of the apps in the Google Play Store, the app´s Terms of Use, the performance spectra and language settings, the user audience of all apps was clearly identifiable, but often required a more extensive search. The same applied to the restrictions on the apps' use, most of which were set out in the Terms of Use, and which, in the case of *Samsung Health* and *My Diet*, did not explicitly exclude the use by children under the age of 13. Fifthly, the provision of a customer hotline or a contact e-mail address is also an important quality criterion, which was available for all of the ten apps tested. Sixthly, none of the considered apps was previously certified by a trusted authority. Finally, considering that all apps were offered in the German Google Play Store, compliance with the German General Data Protection Regulation (GDPR EU 2016/679) was only stated by *Samsung Health* and *Calorie Counter by Lose It!*. For all other apps, no information regarding their GDPR conformity was available.

3.6 Nutrient intake information

The information provided by the selected apps on nutrient values for various food items and general intake recommendations were evaluated in comparison to the German Nutrient Database (BLS). Five typical food items covering different types of meals were deliberately selected (i.e. cornflakes, wild rice, potato bread, gumdrops and raspberries) and the available information regarding the "Big 5" nutrients was further investigated. **Table 6** provides an overview of the extracted nutrient values of those food items as provided by the apps and compares them to the respective BLS values. Overall, the consistency of the nutrient data was found to vary greatly among the different apps and food items examined. The closest match with the BLS nutritional values for the five analyzed foods was found with *Calorie Counter by Lose It!* with 57% agreement followed by *Calorie Counter - MyFitnessPal* with 41%. The nutritional values given in the remaining apps reflected the BLS levels to less than 20%. Regarding the over- and underestimation of BLS values, a similar distribution was found for most of the apps. For *Nutrition Tracker*, the nutrition information provided did not correspond to the BLS. Besides, there were also variations in the amount of values presented by different apps. While *My Diet - Vitamins Tracker*, for example, contained complete information about the "Big 5" nutrients for each of the five foods, *Nutrition Tracker* listed only 80% of this information (missing data for sodium). *Ultimate Workout Nutrition* and *Vegetarian and Vegan Recipes* did not include nutritional information for certain foods. Looking at individual "Big 5" components, *MyFitnessPal* had the lowest average absolute deviations from BLS for calories, fat, carbohydrates and protein. Slightest deviations in sodium content were observed for *MyFitnessPal*, *Nutrition Facts* and *My Diet - Vitamins Tracker*.

As a second approach, the intake recommendations for aforementioned nutrients were examined more closely for consistency with the recommendations of the German Nutrition Society (DGE)[11] on the basis of the DACH reference values (DACH = Germany, Austria and Germany).[12] **Table 7** provides an overview of intake recommendations for energy and selected nutrients given by the tested apps. Out of ten apps, only six contained intake recommendations for specific nutrients. The *Calorie Counter by Lose It!* gave recommendations for total daily caloric intake, while for *Ultimate Workout Nutrition*, *Nutrition Facts* and *Nutrition Tracker* no information was available. *Samsung Health* and *My Diet - Vitamins Tracker* met the DACH recommendations for sodium intake and gave slightly similar once for proteins, for the other nutrients lower intake levels were recommended within the apps. For fats, three out of four apps providing fat intake recommendations, met the fat intake recommendations of the DACH, while *Vegetarian and Vegan Recipes* recommendations were lower. The fat intake recommendations of the calorie counters by *MyFitnessPal* and *FatSecret*, as well as *Recipe IQ: Nutrition Calculator* corresponded to the DACH recommendations, while they exceeded the recommendations for the other nutrients provided. The *Calorie Counter - MyFitnessPal* was the only app providing recommendations on all major nutrients, but proposed higher intake levels than the DACH for sugar, protein and sodium, and lower for total calories, carbohydrates and fibre. With respect to fibre, four apps gave recommendations for daily intake, all of which were below the recommendation of the DACH with an average intake of more than 30g/day.

3.7 App store modifications

Browsing the German Google Play Store for the search term "nutrition" at the beginning of 2019, 250 hits were shown. For the top 50 apps, based on their number of installs and user ratings, a comparative ranking between 2019 and 2020 was performed (**Figure 1**). 40% of the apps that were among the top 50 in 2019 were replaced by different apps in 2020. In contrast to the apps *Calorie Counter by Fat Secret* (position 3) and *Yazio Calorie Counter* (position 8), which maintained their ranks from 2019 to 2020, as well as *FDDB Extender* (2019: position 24), which slightly improved its position in 2020, all remaining apps exhibited a clear downward trend. The most pronounced drops were seen for *IEatWell: Food Diary & Journal Healthy Eating Tracker* (-58 ranks), *Lose weight: diet and exercises in 30 days* (-65 ranks), and *Was ich esse* (-71 ranks). The apps analyzed in this study ranked as follows in 2020 (**Table 1**): 1. *Samsung Health*, 2. *Calorie Counter - MyFitnessPal*, 3. *Calorie Counter by Fat Secret*, 4. *Calorie Counter by Lose It!*, 62. *Ultimate Workout Nutrition*, 84. *Nutrition Facts*, 140. *My Diet - Vitamins Tracker*, 141. *Nutrition Tracker*, 201. *Recipe IQ: Nutrition Calculator* and 224. *Vegetarian and Vegan Recipes*.

4. Discussion

There is a multidimensional understanding of quality,[16] which requires a targeted and differentiated approach and the use of adequate tools for quality assessment. This became particularly obvious when a series of nutrition apps were examined more closely

regarding their quality within this study. A keyword search in the Google Play Store revealed a vast number of nutrition apps, so that an overall assessment was not feasible and necessitated the selection of representative examples. In this context, it is important to note that a keyword search within an app store does not return all available apps and that results may vary over time. Karagkiozidou et al.,[22] for example, reported the number of installations, user ratings and reviews as some of the main aspects contributing to an app's ranking within the Play Store. This links to a user-based perspective on quality, taking into account the different wishes and needs of the users to be satisfied.[16,6] By applying a product-based approach using objective and validated tools and checklists, the apps' qualities were evaluated at different dimensional levels. In connection with this, the AQEL tool was applied, originally designed for use by nutrition experts and researchers and validated by nutrition professionals, app developers and end users.[13] A significant advantage of this instrument is the fact that it is tailored to nutrition-related apps and able to address a wide range of user expectations and target groups. During the analysis, however, some shortcomings were identified. For example, the tool comprises different sub-questions related to the target audiences concerning their level of maturity and cognitive abilities, which are difficult to assess objectively by an external reviewer. Furthermore, some of the AQEL-items regarding behavior change potential, knowledge and skill development appear to be rather subjective (e.g. "Would your friends use this app?"). In some cases, the AQEL scoring depends heavily on the individual perceptions of the evaluator, reflected by discrepancies within the results. To bypass this, an average rating of a large number of testers would be more meaningful. Furthermore, the AQEL tool lacked an overall quality rating score, so that only comparisons between sub-categories could be made.

The MARS score, originally validated on apps for mental health,[30] was used to assess the quality dimensions of nutrition apps regarding engagement, functionality, aesthetics and information content. Compared to the AQEL tool, the MARS scale offers the possibility to consider a subjective category for the qualitative analyses separately to four objective test categories and permits calculating an average score across all the categories examined. This facilitates the comparison of the quality of several apps. When comparing the contents of the AQEL tool with the MARS score, some communalities became apparent. Both include app function or functionality as a rating component, using quite similar questions within the corresponding subdomains. However, a comparison of the scores for this category between the apps yielded different results. Taking *Samsung Health* as an example, an average value of 7.5 on a 10-point-scale was estimated with the AQEL tool compared to a MARS score of 4.8 on a 5-point-scale. Considering the evaluation results and taking the different evaluation scales into account, the average results for functionality across all tested apps were almost 15% higher with the MARS score compared to the AQEL ratings. This shows that quality assessment instruments such as AQEL or MARS are valid on a standalone basis, while individual quality dimensions are not necessarily interchangeable.

Additionally, the ENLIGHT score was applied within this study. Besides general app quality aspects, the score also includes a therapeutically evaluation approach within

its “Quality Assessment Section”, which was disregarded in this paper. The focus was rather put on the ENLIGHT checklists on credibility, evidence-base and privacy explanation. The comparison of ENLIGHT and MARS showed an overlap of the evaluated quality aspects for credibility and evidence-based information. However, ENLIGHT provides an overall score for credibility, while the MARS score integrates questions on credibility and the evidence base, that cannot be considered separately, but are rather included in an overall score for information. Concerning the provision of evidence-based information, both the MARS and ENLIGHT tools emphasize the availability of empirical research results. With regard to the nutrition apps considered in this study, only the two calorie counters from *MyFitnessPal* and *Lose It!* have been investigated in randomized controlled studies.[24,18,2]

The aspect of quality of information provided within an app is only included in the MARS score using the question "Is the app content correct, well written and relevant to the goal/topic of the app?". Based on the results of this study, a sound answer to this question could only be provided following a detailed app analysis. Therefore, knowledge on the implemented nutrient database and reference values for nutrient intakes is required. However, this was only specified in three out of the ten apps reviewed. It also turned out that in the case of *Nutrition Tracker*, for example, an outdated nutrient database was integrated,[1] or in the case of *Samsung Health*, nutrient reference values were tailored for a U.S. or Korean population. Considering these differences in the source of information implemented in the apps, it is not surprising that data on nutrient content and intake reference values are not in line with the BLS values and the DACH recommendations.

None of the analyzed apps providing dietary intake recommendations took the ethnicity of its users into account or adapted the recommendations thereon. *Calorie Counter by Fat Secret*, *Nutrition Facts*, *Nutrition Tracker* and *Vegetarian and Vegan Recipes*, also included food databases with branded products, some of which are not familiar in Europe, making it difficult for German users to select suitable foods. There are also differences between the apps in terms of database searches for individual foods. As mentioned earlier, some apps were developed in non-European countries, which is reflected in the list of suggestions when searching a specific food item. Taking onion tart as an example of a traditional dish, only matches for the databases of *MyFitnessPal*, *Samsung Health*, *FatSecret* and *Lose It!* were found. Based on these findings more international food items needed to be chosen for an in depth-app evaluation. In addition, the target audience was also determined a decisive factor, since, for example, nutrient intake recommendations are known to vary by age, gender, or ethnicity. For our analyses, this was resolved by using identical anthropometric data from a fictitious subject. Lastly, the dietary aims need to be considered, e.g. weight reduction. To remedy this, a stable body weight maintenance was assumed throughout our evaluations.

The aspects of user privacy and basic data protection are not part of either the AQEL or the MARS tool, but are taken into account in ENLIGHT. A comparison of the app store’s subjective user ratings of the analyzed apps, which ranged from 2.8 to 4.7 stars, with the overall quality rating score of MARS showed considerable discrepancies.

While the subjective user rating in the app store suggested *Calorie Counter by FatSecret* to be the best apps, followed by *Lose It!*, and *MyFitnessPal*, the MARS rating identified *Samsung Health*, the calorie counters by *Lose It!* and *MyFitnessPal* as the top three apps in the test. The lowest user rating was accounted for *Nutrition Tracker*, whereas the MARS score rated *Recipe IQ: Nutrition Calculator* worst in regard to quality. These results were consistent with previous findings, which also detected no correlations between user ratings in Google Play and MARS.[15]

This study addressed a selection of nutrition apps and focussed on the evaluation of app quality criteria using different quality assessment tools. As it was not the aim to perform a comprehensive app evaluation of all existing nutrition apps, the results of this study could be biased in terms of sample selection and not be all-encompassing. It should also be noted that the selected apps were evaluated based on their free basic version, while an evaluation of their chargeable premium version could lead to differing results. In addition, all analyses in this study were based on three evaluation tools most commonly used in research on health applications. In this context, it cannot be ruled out that other assessment tools might include further quality aspects relevant for nutrition apps and would therefore possibly produce different evaluation results.

5. Conclusions

Despite a number of tools available for quality assessment of apps focusing on nutrition and health, none of these coherent and self-contained instruments cover all relevant quality aspects at the same time. As this study has shown, the approach of combining several tools to enhance the evaluation was not fully successful, due to content overlaps. In case of the AQEL, MARS and ENLIGHT tool, each was checked for validity before being published, and overlapping quality aspects can therefore not be eliminated without re-validation. It would therefore be desirable to have an all-in-one instrument covering a wider range of quality aspects of nutrition apps and using a uniform, consistent evaluation concept (e.g. 10-point scales).

6. Recommendations

In view of the enormous variety of nutrition apps in the Google Play Store and the wide range of performance components and features (e.g. food scanner, calorie counting, internet website linkage, provision of recipes/dietary information), a basic tool for quality assessment would be sensible, with the possibility of flexibly expanding it to further quality categories or aspects. Given the strong fluctuation of nutrition apps on the market, this would allow a rapid adjustment to changing quality requirements, which is particularly important in light of the speed at which new technical app features evolve. In conclusion, although the present study is certainly not extensive enough, it is groundbreaking in this field and intended to provide the impetus for the development of an all-inclusive quality assessment tool instead of stand-alone instruments, with the aim

of improving the quality level of health apps in the long term and contributing to their quality assurance and user safety.

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Conflicts of interest
The authors declare no conflicts of interest.

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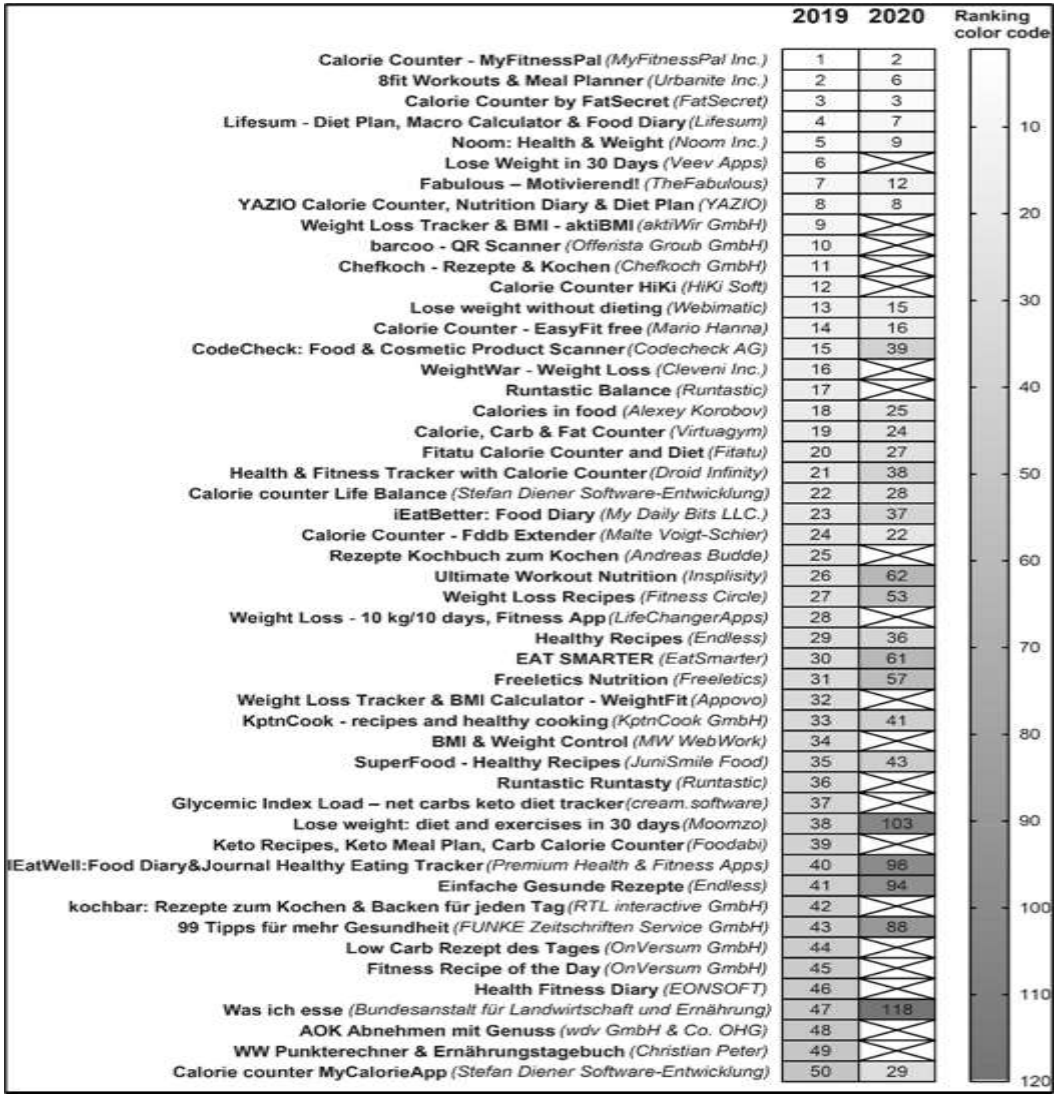
Appendix



	2019	2020
Calorie Counter - MyFitnessPal *(MyFitnessPal Inc.)*	1	2
8fit Workouts & Meal Planner *(Urbanite Inc.)*	2	6
Calorie Counter by FatSecret *(FatSecret)*	3	3
Lifesum - Diet Plan, Macro Calculator & Food Diary *(Lifesum)*	4	7
Noom: Health & Weight *(Noom Inc.)*	5	9
Lose Weight in 30 Days *(Veev Apps)*	6	X
Fabulous – Motivierend! *(TheFabulous)*	7	12
YAZIO Calorie Counter, Nutrition Diary & Diet Plan *(YAZIO)*	8	8
Weight Loss Tracker & BMI - aktiBMI *(aktiWir GmbH)*	9	X
barcoo - QR Scanner *(Offerista Groub GmbH)*	10	X
Chefkoch - Rezepte & Kochen *(Chefkoch GmbH)*	11	X
Calorie Counter HiKi *(HiKi Soft)*	12	X
Lose weight without dieting *(Webimatic)*	13	15
Calorie Counter - EasyFit free *(Mario Hanna)*	14	16
CodeCheck: Food & Cosmetic Product Scanner *(Codecheck AG)*	15	39
WeightWar - Weight Loss *(Cleveni Inc.)*	16	X
Runtastic Balance *(Runtastic)*	17	X
Calories in food *(Alexey Korobov)*	18	25
Calorie, Carb & Fat Counter *(Virtuagym)*	19	24
Fitatu Calorie Counter and Diet *(Fitatu)*	20	27
Health & Fitness Tracker with Calorie Counter *(Droid Infinity)*	21	38
Calorie counter Life Balance *(Stefan Diener Software-Entwicklung)*	22	28
iEatBetter: Food Diary *(My Daily Bits LLC.)*	23	37
Calorie Counter - Fddb Extender *(Malte Voigt-Schier)*	24	22
Rezepte Kochbuch zum Kochen *(Andreas Budde)*	25	X
Ultimate Workout Nutrition *(Insplisity)*	26	62
Weight Loss Recipes *(Fitness Circle)*	27	53
Weight Loss - 10 kg/10 days, Fitness App *(LifeChangerApps)*	28	X
Healthy Recipes *(Endless)*	29	36
EAT SMARTER *(EatSmarter)*	30	61
Freeletics Nutrition *(Freeletics)*	31	57
Weight Loss Tracker & BMI Calculator - WeightFit *(Appovo)*	32	X
KptnCook - recipes and healthy cooking *(KptnCook GmbH)*	33	41
BMI & Weight Control *(MW WebWork)*	34	X
SuperFood - Healthy Recipes *(JuniSmile Food)*	35	43
Runtastic Runtasty *(Runtastic)*	36	X
Glycemic Index Load – net carbs keto diet tracker *(cream.software)*	37	X
Lose weight: diet and exercises in 30 days *(Moomzo)*	38	103
Keto Recipes, Keto Meal Plan, Carb Calorie Counter *(Foodabi)*	39	X
iEatWell:Food Diary&Journal Healthy Eating Tracker *(Premium Health & Fitness Apps)*	40	96
Einfache Gesunde Rezepte *(Endless)*	41	94
kochbar: Rezepte zum Kochen & Backen für jeden Tag *(RTL interactive GmbH)*	42	X
99 Tipps für mehr Gesundheit *(FUNKE Zeitschriften Service GmbH)*	43	88
Low Carb Rezept des Tages *(OnVersum GmbH)*	44	X
Fitness Recipe of the Day *(OnVersum GmbH)*	45	X
Health Fitness Diary *(EONSOFT)*	46	X
Was ich esse *(Bundesanstalt für Landwirtschaft und Ernährung)*	47	118
AOK Abnehmen mit Genuss *(wdv GmbH & Co. OHG)*	48	X
WW Punkterechner & Ernährungstagebuch *(Christian Peter)*	49	X
Calorie counter MyCalorieApp *(Stefan Diener Software-Entwicklung)*	50	29

Ranking color code: 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120

Figure 1: Top 50 hits of a keyword search for "nutrition" in the German Google Play Store. All hits were sorted in descending order according to the number of app downloads, the user´s average star ratings and the number of ratings. Apps that were not listed in 2020 are marked with an "X".

Table 1: General app information

Application / Information	Samsung Health	Calorie Counter - MyFitnessPal	Calorie Counter by FatSecret	Calorie Counter by Lose It!	Ultimate Workout Nutrition	Nutrition Facts	Nutrition Tracker	My Diet - Vitamins Tracker	Recipe IQ: Nutrition Calculator	Vegetarian and Vegan Recipes
Developer	Samsung Electronics Co., Ltd	MyFitnessPal, Inc.	FatSecret	FitNow, Inc.	Insplisity	Alexey Korobov	Meuuha Apps	Healthy Lifestyle	Interstitial Solutions LLC	Jappli Gym Fitness Team
Country of origin	Rep. of Korea	US	Australia	US	Slovenia	Kazakhstan	France	N/A	US	Colombia
Updated	12/24/2019	01/29/2020	02/11/2020	01/31/2020	10/16/2019	02/01/2019	05/29/2018	03/27/2018	01/21/2020	01/27/2019
Current version	6.8.5.009	Varies with device	Varies with device	Varies with device	1.10	1.8	3.0.7	2.1	01.05.2005	1.0.1
Language	German	German	German	German	German	English	English	English	English	English
Google Play Store category	Health & Fitness	Health & Fitness	Health & Fitness	Health & Fitness	Food & Drink	Health & Fitness	Health & Fitness	Health & Fitness	Food & Drink	Food & Drink
Focus	Diet, Wellness, Fitness	Diet, Fitness	Diet, Weight control	Diet, Weight control	Diet, Weight control, Muscle gain	Diet, Weight control, Nutrition education	Diet tracking	Diet tracking	Healthy diet promotion, Recipe calculation	Diets, Recipe calculation
Star rating (January 2020)	4.3	4.5	4.7	4.6	3.5	3.8	2.7	3.4	2.9	2.8
Google Play Store ranking position (January 2019)	Not listed	1	3	Not listed	26	Not listed	Not listed	95	Not listed	Not listed
Google Play Store ranking position (January 2020)	1	2	3	4	62	84	141	140	201	224

Table 2: AQEL scores of selected nutrition apps

Application / Quality ratings	Samsung Health	Calorie Counter - MyFitnessPal	Calorie Counter by FatSecret	Calorie Counter by Lose It!	Ultimate Workout Nutrition	Nutrition Facts	Nutrition Tracker	My Diet - Vitamins Tracker	Recipe IQ: Nutrition Calculator	Vegetarian and Vegan Recipes
Behavior change potential	6.0	5.6	5.2	6.0	6.0	4.8	5.2	4.8	4.4	5.2
Support of Knowledge Acquisition	7.3	5.0	5.9	6.8	5.5	3.2	5.9	4.5	4.1	7.3
Skills Development	2.2	2.2	2.2	3.3	2.2	2.2	2.2	2.2	2.2	6.7
App Function	7.5	7.5	7.1	7.9	5.8	6.7	7.5	5.8	4.2	4.6
App Purpose	8.3	6.7	10.0	10.0	10.0	6.7	8.3	8.3	8.3	10.0
Appropriateness for target audience:										
A) Teenagers	N/A	N/A	5.0	N/A	N/A	5.0	5.0	N/A	4.0	5.0
B) Adults	N/A	9.0	6.0	9.0	5.0	5.0	8.0	N/A	5.0	5.0
C) General audience	7.0	N/A	N/A	N/A	N/A	N/A	N/A	5.0	N/A	N/A
Appropriateness to satisfy users' expectations										
A) Seeking weight loss support	7.5	6.3	5.0	5.0	N/A	N/A	5.0	N/A	5.0	6.3
B) Seeking support for specific nutrition concerns	N/A	N/A	N/A	N/A	8.0	N/A	N/A	6.3	N/A	7.5
C) Seeking for nutrition education	6.3	N/A	N/A	N/A	N/A	1.3	5.0	N/A	N/A	7.5
D) Seeking for recipes/ meal ideas	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5.0
E) Other	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	N/A

Note: Data are shown as mean of two raters and sum scores for quality domains. All sum scores were converted to a 10-point scale for comparison and a score of ≥8 is equated with high quality; N/A: Not applicable.

Table 3: MARS scores of selected nutrition apps

Application / Quality score	Samsung Health	Calorie Counter - MyFitnessPal	Calorie Counter by FatSecret	Calorie Counter by Lose It!	Ultimate Workout Nutrition	Nutrition Facts	Nutrition Tracker	My Diet - Vitamins Tracker	Recipe IQ: Nutrition Calculator	Vegetarian and Vegan Recipes
Engagement	3.6	3.4	3.0	3.4	2.4	1.6	3.4	2.8	2.0	3.2
Functionality	4.8	4.3	4.0	4.5	4.0	4.8	4.0	3.5	2.5	3.3
Aesthetics	5.0	4.0	3.0	4.0	3.3	3.0	4.0	3.0	2.3	3.3
Information	4.4	4.0	3.2	4.4	3.8	2.5	3.8	3.8	2.7	3.8
Average score	4.5	3.9	3.3	4.1	3.4	3.0	3.8	3.3	2.4	3.4

Note: Data are shown as mean scores of n=2 raters. All scores are rated on a 5-point scale and to interpret as 5=excellent; 4=good; 3=acceptable; 2=poor; 1=inadequate.

Table 4: ENLIGHT scores of selected nutrition apps

Application / Quality score	Samsung Health	Calorie Counter - MyFitnessPal	Calorie Counter by FatSecret	Calorie Counter by Lose It!	Ultimate Workout Nutrition	Nutrition Facts	Nutrition Tracker	My Diet - Vitamins Tracker	Recipe IQ: Nutrition Calculator	Vegetarian and Vegan Recipes
Credibility	6.0	10.0	8.0	8.0	4.0	3.0	2.0	2.0	4.0	2.0
User Privacy	0.0	0.0	2.0	1.0	2.0	6.0	5.0	8.0	2.0	8.0
Security (Data Collection /Transmission	3.0	1.0	2.0	1.0	2.0	4.0	4.0	4.0	2.0	3.0

Note: Data are shown as means of n=2 raters. Interpretations of ENLIGHT scores: a) Credibility [1=can´t be accounted for; 2=poor; 3-4=fair; 5=good; 6-7=very good; >8=excellent]; b) User Privacy (0-8 points); lower scores equate to better quality while a score of 0 indicates that the data protection requirements of the users are sufficiently met; c) Security (0-4 points); lower scores equate to better security while a score of 0 indicates that user data are reasonably secured.

Table 5: Advanced app quality indicators and test metrics

Application / Quality dimension	Samsung Health	Calorie Counter - MyFitnessPal	Calorie Counter by FatSecret	Calorie Counter by Lose It!	Ultimate Workout Nutrition	Nutrition Facts	Nutrition Tracker	My Diet - Vitamins Tracker	Recipe IQ: Nutrition Calculator	Vegetarian and Vegan Recipes
Transparency										
Type of advertisement (examples)	Smartphone (Samsung Galaxy)	Third-party products (e.g. Audible & Fitness apps), Car advertisement (e.g. Dacia Duster), etc.	N/A	Wearables (e.g, Fitbit, Garmin), Apps (e.g. Strava), Devices (e.g. Fitbit Aria), etc.	Extensive use of cookies, Instagram, Google Play Store, Amazon shopping, etc.	Ebay small ads, Instagram, Google Play, Magazines (e.g. salesfore), etc.	Instagram, Magazines (e.g. sales-force), vfa pharma, Audible, etc.	N/A	Wish (appstore), websites (e.g. boden-burg, rgp catering manage-ment), etc.	Wish (appstore), Zalando, Bofrost, dental care videos, etc.
Web link target	Magazines (e.g. Fit for Fun)	N/A	N/A	N/A	N/A	Wikipedia	N/A	N/A	N/A	N/A
Information on databases/guidelines integrated	Harris-Benedict-equation (Roza and Schizgal, 1984), Reference values for nutrient intake (Institute of Medicine of the National Academics, 2005), Reference values for nutrient intake for Koreans (The Korea Nutrition Society, 2010)	N/S	N/S	N/S	N/S	N/S	Table of food composition Ciqual 2012, USDA National Nutrient Database	RDI based on the Institute of Medicine's Food and Nutrition Board	N/S	N/S
Timeliness										
Actuality of the information provided	Limited	N/S	N/S	N/S	N/S	N/S	Limited	N/S	N/S	N/S
Appropriateness										
Specification of the target audience (based on app content, language settings, etc.)	German- speaking people, Koreans, Americans, Canadians	German-speaking people interested in weight loss	German-speaking people, calorie counters	German-speaking people interested in weight loss	German-speaking people interested in muscle building, weight loss, sports nutrition	English-speaking people, American Indians/ Alaska Natives, Vegetarians	English speaking people interested in weight management	English speaking people with special diets (e.g. Vegetarians, Pescetarians)	English speaking people who wish to eat healthy	English speaking people, Vegans, Vegetarians

Specification of restricted app use	USK minimum age: 0 years	Persons <18 years, teenagers 13-18 years without parental supervision	Exclusion of children <13 years	Exclusion of pregnant women, persons <18 years	Exclusion of persons with high blood pressure or heart diseases, children <13 years	Exclusion of children <13 years	Exclusion of children <13 years	USK minimum age: 0 years	Exclusion of children <13 years	Exclusion of children <13 years
Availability										
Customer hotline or e-mail contact information	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Credibility										
App certification with a quality certificate (e.g. HealthOn, Trusted APP ePrivacyApp,)	No	No	No	No	No	No	No	No	No	No
Security										
Compliance with the General Data Protection Regulation (EU) 2016/679	Yes	No	No	Yes	No	No	No	No	No	No

Note: N/A: Not applicable; N/S: Not specified; RDI: Recommended Daily Intake; USK: *Entertainment Software Self-Regulation* Body

Table 6: Nutrient values for selected food items

Food item	German Nutrient Data Base* (BLS code)	Samsung Health	Calorie Counter - MyFitnessPal	Calorie Counter by FatSecret	Calorie Counter by Lose It!	Ultimate Workout Nutrition	Nutrition Facts	Nutrition Tracker	My Diet - Vitamins Tracker	Recipe IQ: Nutrition Calculator	Vegetarian and Vegan Recipes
1. Cornflakes	Cornflakes (C515000)	Cornflakes	Cornflakes	Cornflakes	Cornflakes	–	Kellog's Cornflakes (ready-to-go)	Kellog's Cornflakes (ready-to-go)	Kellog's Cornflakes (ready-to-go)	Kellog's Cornflakes (crumbs)	–
Calories (kcal) BLS deviation (%)	360.0	360.0 0.0	333.3 -7.4	360.0 0.0	360.0 0.0	No entry of single foods possible	356.6 +0.9	357.0 +0.8	365.0 +1.4	366.6 +1.8	No information provided
Fat (g) BLS deviation (%)	0.6	0.1 -83.3	0.0 0.0	0.1 -83.3	0.7 +16.7		0.4 -33.3	0.3 -50.0	0.6 0.0	0.0 0.0	
Carbs (g) BLS deviation (%)	79.7	86.7 +8.8	80.0 0.4	86.7 +8.8	79.7 0.0		84.1 +5.5	84.0 +5.4	87.0 +9.2	83.3 +4.5	
Protein (g) BLS deviation (%)	7.7	6.7 -13.0	6.7 -13.0	6.7 -13.0	N/S -		7.5 -2.6	7.3 -5.2	6.6 -14.3	N/S -	
Sodium (mg) BLS deviation (%)	960	949.0 -1.1	666.6 -30.6	949.9 -1.1	959.9 0.0		729.0 -24.1	N/S -	723.0 -24.7	636.6 -33.7	
2. Wild rice, cooked	Wildreis gekocht (C353132)	Wildreis gekocht	Wildreis gekocht (Atry)	Wildreis gekocht	Wildreis gekocht	–	Wild rice, cooked	Wild rice, cooked	Wild rice, cooked	Wild rice, cooked	–
Calories (kcal) BLS deviation (%)	134.0	101.2 -24.5	133.9 -0.1	101.1 -24.6	133.9 -0.1	No entry of single foods possible	101.1 -24.6	101.0 -24.6	101.0 -24.6	101.1 -24.6	No information provided
Fat (g) BLS deviation (%)	0.4	0.3 -25.0	0.4 0.0	0.3 -25.0	0.4 0.0		0.3 -25.0	0.3 -25.0	0.3 -25.0	0.6 +50.0	
Carbs (g) BLS deviation (%)	26.9	21.3 -20.8	26.9 0.0	21.3 -20.8	26.9 0.0		21.3 -20.8	21.3 -20.8	21.3 -20.8	21.1 -21.60	

Protein (g) BLS deviation (%)	5.3	4.0 -24.5	5.3 0.0	4.0 -24.5	5.3 0.0		4.0 -24.5	4.0 -24.5	4.0 -24.5	3.9 -26.4	
Sodium (mg) BLS deviation (%)	2.0	3.1 +55.0	2.0 0.0	2.8 +40.0	2.0 0.0		3.0 +50.0	N/S -	3.0 +50.0	2.8 +40.0	
3. Bread, potato	Kartoffelbrot (B710400)	Kartoffelbrot	Kartoffelbrot	Kartoffelbrot	Kartoffelbrot	–	Bread, potato	Bread, potato	Bread, potato	Bread, potato	–
Calories (kcal) BLS deviation (%)	243.0	263.7 +8.5	216.0 -11.1	266.0 +9.5	244.0 +0.4	No entry of single foods possible	266.0 +9.5	266.0 +9.5	266.0 +9.5	266.0 +9.5	No information provided
Fat (g) BLS deviation (%)	1.3	3.2 +146.2	1.4 +7.7	3.2 +146.2	1.4 +7.7		3.1 +138.5	3.2 +146.2	3.1 +138.5	4.0 +207.7	
Carbs (g) BLS deviation (%)	48.8	50.4 +3.3	41.0 -16.0	50.6 +3.7	48.8 0.0		47.1 -3.5	47.0 -3.7	47.1 -3.5	48.0 -1.6	
Protein (g) BLS deviation (%)	8.0	7.6 -5.0	7.0 -12.5	7.6 -5.0	8.0 0.0		12.5 +56.3	12.4 +55.5	12.5 +56.3	12.0 +50.0	
Sodium (mg) BLS deviation (%)	330.0	679.8 +106.0	N/S -	682.0 +106.7	330.0 0.0		375.0 +13.6	N/S -	375.0 +13.6	376.0 +13.9	
4. Gumdrops	Gummibonbons (S360000)	Gummibären	Gummibärchen, Gummibonbons	Gummibärchen, Gummibären	Gummibonbons	–	Gumdrops, starch jelly pieces	Gumdrops, starch jelly pieces	Gumdrops, starch jelly pieces	Gumdrops, starch jelly pieces	–
Calories (kcal) BLS deviation (%)	348.0	395.9 +13.8	333.5 -4.2	393.5 +13.1	346.8 -0.3	No entry of single foods possible	396.9 +14.1	396.2 +13.9	396.0 +13.8	393.5 +13.1	No information provided
Fat (g) BLS deviation (%)	0	N/S -	0.0 0.0	N/S -	N/S -		N/S -	0.0 0.0	0.0 0.0	N/S -	
Carbs (g)	78.6	98.7	N/S	99.0	78.7		99.0	98.7	98.9	100.1	

BLS deviation (%)		+25.6	-	+26.0	+0.1		+26.0	+25.6	+25.8	+27.4	
Protein (g)	6.6	N/S	6.0	N/S	6.7		N/S	0.0	0.0	N/S	
BLS deviation (%)		-	-9.1	-	+1.5		-	0.0	0.0	-	
Sodium (mg)	62.0	45.5	N/S	46.7	62.0		44.0	N/S	44.0	46.7	
BLS deviation (%)		-26.6	-	-24.7	0.0		-29.0	-	-29.0	-24.7	
5. Raspberries	Himbeere roh (F302100)	Himbeeren	Himbeere	Himbeeren	Himbeere, frisch, Eat Me	–	Raspberries, raw	Raspberry, raw	Raspberry, raw	Rasp berry raw	–
Calories (kcal)	34.0	52.0	34.4	52.0	35.2	No entry of single foods possible	52.0	52.0	52.0	52.0	No information provided
BLS deviation (%)		+52.9	+1.2	+52.9	+3.5		+52.9	52.9	+52.9	+52.9	
Fat (g)	0.3	0.6	0.3	0.7	0.0		0.7	0.6	0.7	1.0	
BLS deviation (%)		+100	0.0	+133.3	0.0		+133.3	+100.0	+133.3	+233.3	
Carbs (g)	4.8	11.9	4.8	11.9	4.5		12.0	11.9	12.0	9.6	
BLS deviation (%)		+147.9	0.0	+149.9	-6.2		+150.0	+149.9	+150.0	+100.0	
Protein (g)	1.3	1.2	1.3	1.2	1.4		1.2	1.2	1.2	0.8	
BLS deviation (%)		-7.7	0.0	-7.7	+7.7		-7.7	-7.7	-7.7	-38.5	
Sodium (mg)	1.0	1.0	1.3	0.8	0.0		1.0	N/S	1.0	0.8	
BLS deviation (%)		0.0	+30.0	-20.0	0.0		0.0	-	0.0	-20.0	
Compliance of the app´s output with the BLS	Total number of entries provided (no data entry)	23 (2)	22 (3)	23 (2)	23 (2)	- -	23 (2)	20 (5)	25 (0)	22 (3)	- -
	% of positive BLS deviations (total number)	47.8 (11)	18.2 (4)	43.5 (10)	30.4 (7)	- -	52.2 (12)	50.0 (10)	48.0 (12)	59.1 (13)	- -
	% of BLS compliance (total number)	8.7 (2)	40.9 (9)	8.7 (2)	56.5 (13)	- -	4.4 (1)	0.0 (0)	16.0 (4)	4.6 (1)	- -

	% of negative BLS deviations (total number)	43.5 (10)	40.9 (9)	47.8 (11)	13.0 (3)	- -	43.5 (10)	50.0 (10)	36.0 (9)	36.4 (8)	- -
Average absolute deviation from the BLS over all five foods (in %)	Calories	+18.6	+3.9	+18.3	+1.1	-	+18.6	+18.6	+18.2	+18.0	-
	Fat	+88.6	+32.6	+97.0	+40.6	-	+82.5	+71.1	+69.2	+122.8	-
	Carbs	+46.0	+6.1	+46.6	+2.0	-	+47.4	+47.4	+52.3	+33.6	-
	Protein	+6.2	+5.5	+6.2	+2.7	-	+25.5	+36.7	+35.4	+36.6	-
	Sodium	+41.3	+20.3	+42.5	+32.0	-	+23.8	-	+23.9	+25.5	-

Note: *: Nutrient values are indicated per 100g food; N/S=Not specified; Carbs=Carbohydrates; BLS=German Nutrient Database.

Table 7: Intake recommendations for selected nutrients

Application / Food Item	German Nutrition Society	Samsung Health	Calorie Counter - MyFitnessPal	Calorie Counter by FatSecret	Calorie Counter by Lose It!	Ultimate Workout Nutrition	Nutrition Facts	Nutrition Tracker	My Diet - Vitamins Tracker	Recipe IQ: Nutrition Calculator	Vegetarian and Vegan Recipes
Calories (total) (kcal/day)	1800	1441	1730	14000	2011	N/S	N/S	N/S	1735	2000	1843
Fat (g/day)	45-80	N/S	58	52	N/S	N/S	N/S	N/S	N/S	<65	40
Carbs (g/day)	225-275	N/S	216	438	N/S	N/S	N/S	N/S	130	<300	207
Proteins (g/day)	48	46	87	175	N/S	N/S	N/S	N/S	46	N/S	161
Sodium (mg/day)	1500	1500	2300	N/S	N/S	N/S	N/S	N/S	1500	<2400	N/S

Note: All recommendations are provided for a female person, 38 years old, 165 cm in size, 70 kg in weight and with a low level of physical activity (PAL value=1.4); Carbs=Carbohydrates; N/S: Not specified.