Feasibility Evaluation of an Android-based Nutrition App (Dietducate) Among Nutritionists Using the User Version of The Mobile Apps Rating Scale (uMARS)

Muhammad Iqbal [1]*, Elita Dwi Nurrahmawati [2] dan Husin[3]

[1] Politeknik Negeri Jember; iqbalbasagili@polije.ac.id
[2] Politeknik Negeri Jember; elitadwin@gmail.com
[3] Politeknik Negeri Jember, husin@polije.ac.id
* Correspondence: iqbalbasagili@polije.ac.id

Abstract: Online nutrition consultations are one of the strategic measures utilized to address complex nutritional issues. The use of smartphones in Indonesia is on the rise, particularly smartphones with the Android operating system. Indonesia has entered the 4.0 Industrial Revolution, which involves the application of technology in a variety of fields, including the healthcare industry. One application of this technology is the creation of the android application "dietducate." Using the uMARS (End-User Version of The Mobile Apps Rating Scale) method, this study aims to assess the feasibility of the android-based health application "dietducate" for nutritionists. Utilizing the uMARS research method and a 5-point scale, the research design is quantitative. Using a technique of purposive sampling, up to 35 nutritionists were gathered as subjects. The application evaluation was conducted using the uMARS questionnaire. The results indicated that the application quality score was within the acceptable range (4.05 out of 5). The component outcomes are determined by four supporting factors: involvement, functionality, aesthetics, and information. The results of each score are 3.97, 4.03, 4.02, and 4.23, respectively. It can be concluded that nutritionists can utilize the dietducate application. This app is also regarded as user-friendly and efficient for completing nutritionists' work. However, there are too many advertisements and minor bugs that need fixing to optimize app performance.

Keywords: Nutrition App, Dietducate, Feasibility Evaluation, uMARS.

Abstrak:

Salah satu upaya strategis dalam mengatasi permasalahan gizi yang kompleks ialah melalui konsultasi gizi secara online. Penggunaan smartphone di Indonesia semakin meningkat terutama pada smartphone dengan OS Android. Indonesia telah memasuki revolusi Industri 4.0 yaitu pemanfaatan teknologi di berbagai bidang, termasuk bidang kesehatan. Salah satu bentuk pemanfaatan teknologi ini adalah pengembangan aplikasi android "dietducate". Penelitian ini bertujuan untuk mengevaluasi kelayakan aplikasi kesehatan berbasis android "dietducate" pada ahli gizi menggunakan metode uMARS (End-User Version of The Mobile Apps Rating Scale). Desain penelitian yang digunakan ialah kuantitatif dengan metode penelitian uMARS dengan skala 5 poin. Teknik pengambilan subjek menggunakan teknik purposive sampling sebanyak 35 orang ahli gizi. Aplikasi dievaluasi menggunakan kuesioner uMARS. Hasil penelitian menunjukkan skor kualitas aplikasi dalam kategori baik (4,05/5). Komponen hasil tersebut didapatkan dari 4 aspek menunjang yaitu aspek keterlibatan, fungsionalitas, estetika dan informasi. Adapun hasil skor masing-masing secara berurutan 3,97; 4,03; 4,02; 4,23. Dapat disimpulkan aplikasi dietducate layak digunakan pada

ahli gizi. Aplikasi juga dianggap mudah digunakan dan efektif dalam menyelesaikan pekerjaan ahli gizi. Namun terdapat terlalu banyak iklan dan bug-bug kecil yang perlu diperbaiki untuk memaksimalkan kinerja aplikasi.

Kata kunci: Aplikasi kesehatan, Dietducate, Kelayakan aplikasi, uMARS.

1. Introduction

In parallel with the epidemiological transition, Indonesia's nutritional issues are becoming increasingly complex. Multiple nutritional issues, including overnutrition and degenerative diseases, are on the rise. The prevalence of non-communicable diseases, such as stroke, cancer, hypertension, diabetes, and chronic kidney disease, has also increased since Riskesdas 2013 (Basic Health Research) [1]. Many causes of nutritional issues are rooted in society's erroneous beliefs, attitudes, and practices [2]. To address these diverse issues, health professionals are required, particularly nutritionists who can contribute to health service efforts [3]. Nutrition education and consultation is one of the strategic approaches used to increase attitude and behavior changes [2]. Nutritionists also serve as educators, extension agents, trainers, and nutrition consultants [4]. In addition, providing nutrition consultations can influence behavior modification [5].

The obstacles encountered in efforts to improve community nutrition require a more innovative and integrated approach from all parties involved. The times have begun to enter the Industrial Revolution 4.0, also known as the digital revolution, which is characterized by the use of digital technology in various fields, including the health sector [6]. The use of technology will at least solve geographical, temporal, and socioeconomic issues[7]. In addition, the use of smartphones is increasing annually in Indonesia, where there are 338.2 million mobile phone users and 175.4 million internet users, or 64% of the population [8]. Android is the predominant smartphone operating system in Indonesia, accounting for 92.14 percent [9].

According to previous research, the use of smartphone applications as a health promotion innovation is feasible [10]. The outcomes of nutrition education via android smartphone media can improve nutritional knowledge, attitudes, and behavior [11]. With online nutrition consultations, nutrition services play an active role in supporting healthy lifestyles and disease prevention efforts. Online nutrition consultations can overcome problems with nutrition services that are more commonly encountered in conventional consultations [12]. It has been suggested that smartphone applications could provide evidence-based health information to assist individuals in making more informed decisions regarding diet and exercise [13].

The development of the application "Dietducate" is an example of technological progress. The application is an Android application with a diet consultation function, which analyzes the nutritional value of food and provides nutrition education. AhliGiziID released the dietducate application on the Play Store on January 15, 2020. The dietducate application can be used as a resource to obtain information on how to achieve the ideal body weight, according to previous research. This application can assist in managing healthy and nutritious eating patterns, including weight loss and gain [14]. The results of the study indicate that the dietducate application can be accepted by the greater community, beginning at the secondary school level and extending to institutions of higher education. The majority of users are also pleased with the application being developed, as indicated by an average rating of over 80% for usability, satisfaction, and ease of use [15]. According to the average value of system, user, interaction, information, and function aspects for similar applications, the "NutriHealth" application is user-friendly and can be well received by respondents, based on the findings of other studies [16].

However, there is currently no feasibility test for nutritionists using the dietducate application. It is essential to conduct an application feasibility test to determine whether the application can be utilized in accordance with the requirements of users, particularly nutritionists. Engagement and functionality are application design elements that influence the user's intent to continue using the application [17-18]. Recently popular uMARS (end-user of version Mobile App Rating Scale) is one of the tools used to evaluate the feasibility of an application. uMARS is a straightforward, objective, and reliable tool for evaluating the quality of mobile health applications. On a 5-point scale, uMARS rates the dimensions of engagement, functionality, aesthetics, information, and subjective quality (1. Poor - 5. Very Good) [19]. uMARS provides a more comprehensive evaluation than any other app quality metric [20]. uMARS is one of the most widely used app evaluation tools ever developed [21]. In addition, consumers and researchers can utilize the uMARS scale with ease [17]. The authors are interested in further investigating the feasibility evaluation of the android-based health application "dietducate" for nutritionists using the uMARS (end-user of version Mobile) method in light of the aforementioned issues. App Score Scale). In Addition, research using the uMARS method is still very limited in Indonesia, especially those used in health applications.

2. Materials and Methods

The most popular measure for assessing the value and content of Mobile Health Apps (MHA) is the user of version Mobile Application Rating measure (uMARS). The uMARS, a multidimensional tool for evaluating MHA quality, was created using semantic analysis and literary synthesis of the pertinent literature [22]. The quantitative uMARS research method is utilized for the quantitative research design. On a 5-point scale, uMARS evaluates the dimensions of engagement, functionality, aesthetics, information, and subjective quality in health applications. Purposive sampling technique for obtaining samples of subjects. This study's inclusion criteria required nutritionists to be willing to complete questionnaires, utilize the dietducate application, and have Internet access. In the meantime, nutritionists who used the dietducate application for more than one day were excluded.
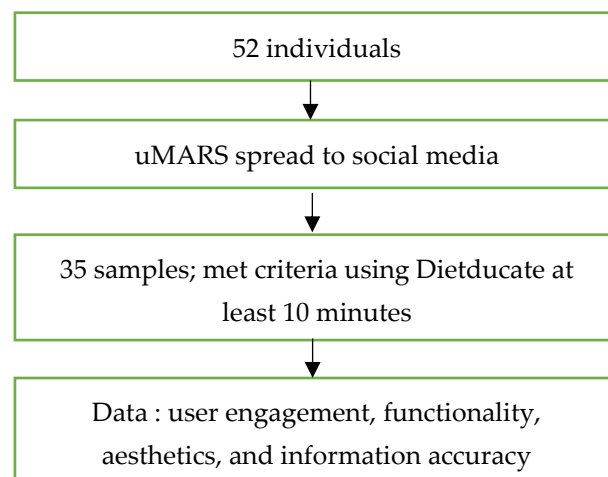

Figure 1. Collecting Data Flowchart

This study's data collection occurred in June 2021. 52 individuals completed the questionnaire, but only 35 met the inclusion requirements. Using the uMARS questionnaire is the method for collecting research data. Through social media, the uMARS questionnaire was distributed online. Prior to completing the questionnaire, respondents were instructed to utilize the dietducate application for 10 minutes to optimize results. Using a five-point Likert scale, the uMARS questionnaire evaluates four application categories: user engagement, functionality, aesthetics, and information accuracy. The sum of the

scores for each category yields an overall objective and subjective quality score. meanwhile, descriptive analysis is used for data analysis.
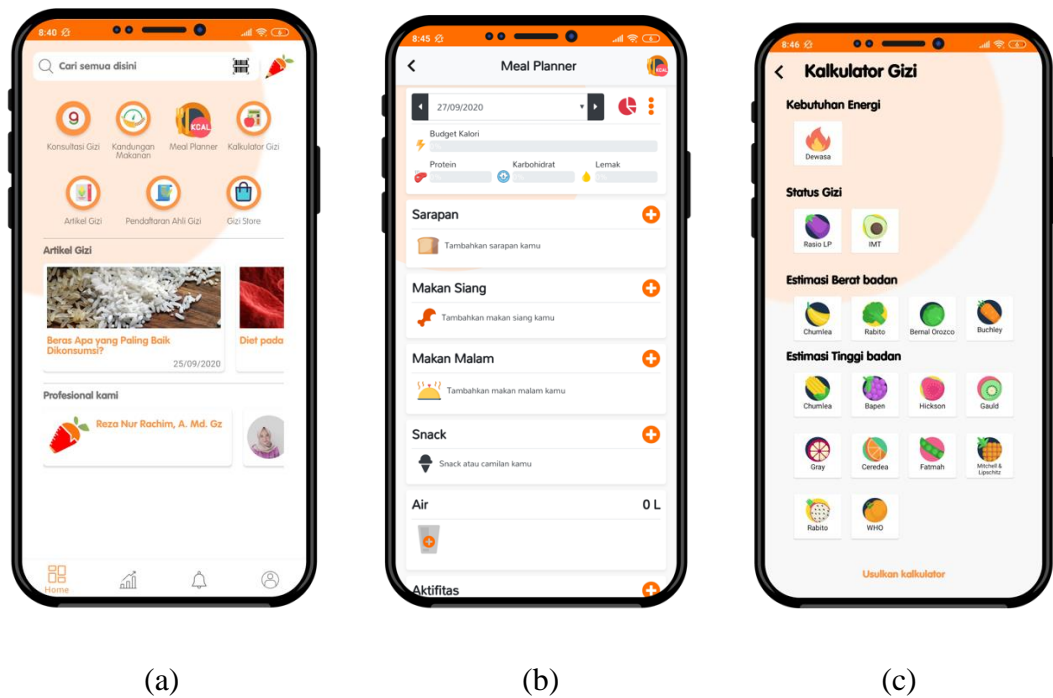

(a)   (b)   (c)

Figure 2. The highlight of Dietducate App. (a) Main Menu of Dietducate (b) meal planner feature used to calculate and evaluate a menu (c) Nutritional Calculator, consisting of some high-used formulas in nutrition.

3. Results

This research was conducted online by distributing questionnaires through social media (WhatsApp, Telegram, and Instagram) to get respondents. In June 2021, the distribution of the questionnaire took place. 52 individuals completed the questionnaire, but only 35 met the criteria for inclusion. In this study, participants provide informed consent and complete the uMARS questionnaire via an online form. Before filling out the questionnaire, respondents were asked to use the dietducate application first for ± 10 minutes.

3.1. Characteristics of Respondents

Table 1. distribution and frequency of respondents

No	Variable	Total (n=35)	%
1	**Gender**		
	Male	2	5,7
	Female	33	94,3
2	**Length of using Dietducate**		
	1-7 Days	3	8,5
	2-3 weeks	3	8,5
	1-6 months	12	34,2
	7-12 months	5	14,2
	> 1 year	12	34,2

According to Table 1, 94.2% of the 35 respondents were female. The respondents who used the application the longest were those who had done so for 1-6 months and > 1 year with the same percentage, 34.2%. On the other hand, only 3 individuals (8.5%) used

Dietducate for 1-7 days, which was the same number and percentage of respondents as those who used the application for 2-3 weeks.

3.2. uMARS Score

Table 2. Test reliability of the user version of the Mobile App Rating Scale

No	Subscale/Item	Score
1	**Engagement**	**3,97**
	Entertainment	3,82
	Interest	4,2
	Customization	4,03
	Interactivity	3,4
	Target group	4,42
2	**Functionality**	**4,03**
	Performance	3,94
	Ease of use	4,1
	Navigation	3,94
	Gestural design	4,14
3	**Aesthetics**	**4**
	Layout	4,02
	Graphics	3,88
	Visual appeal	4,1
4	**Information**	**4,23**
	Quality of Information	**4,11**
	Quantity of Information	**4,17**
	Credibility of Source	**4,42**
5	TOTAL uMARS[a]	4,05
6	**Subjective Items**	**3,74**
	Would you recommend	4,28
	How many times	4
	Would you pay	2,4
	Overall (all) rating	4,31
7	**Behavior Change**	**4,2**
	Awareness	4,37
	Knowledge	4,42
	Attitude	4,2
	Intention to change	4,02
	Looking for help	4,37
	Behavior change	3,97

[a]uMARS : user version of the Mobile App Rating Scale for measure Object Quality App

On engagement items. The obtained scores range from 1 to 5, with a mean of 3.97. The engagement score is derived from responses to five questions regarding entertainment, interest, customization, interactivity, and suitability for the application's target audience. With a mean score of 4.42, target group is the favorable rating for the "engagement" subscale. But entertainment received the lowest rating (average 3.82).

Scoring for functionality ranges from 1 to 5 (mean 4.03). The functionality score is compiled from four questions regarding performance, ease of use navigation, and gestural design. In the Functionality subcategory, gesture design receives the greatest average score of 4.14. However, performance and navigation received the lowest grade, 3.94.

The range of aesthetic scores was between 3 and 5. (mean 4). Aesthetic score compiled from several aesthetic queries, visual appeal, and graphics. Visual appeal receives the greatest average score (4.1), while graphics receive the lowest average score (average 3.88).

Information scores varied between 3 and 5. (mean 4.23). Three questions comprise the information score: information quality, information quantity, and source credibility. Credibility receives a high average score of 4.42 in the information category. However, information quality receives the lowest score (average 4.11). The uMARS score is 4.05 (maximum score = 5) and this score is the average of the scores obtained in the subcategories Engagement, Functionality, Aesthetics, and Information.

Subjective scores varied between 1 and 5. (mean 3.74). The score is based on four questions regarding the likelihood of recommending the app to others, the frequency of use within the next 12 months, the probability of paying for the app, and the app's overall star rating. The question regarding the application's overall star rating provides the greatest score (average 4.31). While the question regarding the possibility of paying for the application produces the lowest score (average 2.4).

The range of behavior change scores is from 1 to 5. (average 4.2). The score is derived from questions regarding awareness, knowledge, attitude, intent to change, looking for help, and behavior change. The highest scores are awarded for questions that increase knowledge (average 4.42). While questions regarding behavior change yield the lowest score (average 3.97).

4. Discussion

The dietducate application is deemed to be of good quality (4.05/5). The evaluation of application quality is based on the average score of four factors: engagement, functionality, aesthetics, and information. Among the four sections evaluated by uMARS, the information section is the best (4.23/5). This is consistent with the development of the dietducate application, which aims to make it easier for users to comprehend accurate information through the use of empirical research [15]. In addition, evidence-based practice enhances nutritionists' credibility with other members of the healthcare team and makes their practice more effective and efficient [21]. There is the potential for applications to provide evidence-based health information to assist users in making better decisions regarding diet and physical activity [13]. In addition, a solid body of evidence can promote app adoption and enhance user health [23].

Functionality and aesthetic value of the application are rated highly (4.03; 4.02). These results support the hypothesis that people prefer applications that are functionally sound and simple to use [24]. User experience/UX is influenced more positively by design elements such as usability, navigation, graphics, and visual appeal [25]. In addition, the user's intention to continue using the application is influenced by the application's usability [26]. While other aspects, such as involvement, received nearly satisfactory ratings (3.97/5). Applications that provide additional interactive features, such as behavioral tracking and semi-automatic options, that make it easier for users to use the application can increase engagement, the attractiveness of the application, and the likelihood of repeat use [17], [20].

The results revealed that the part of the respondents were seasoned users of the dietducate application. This may be attributable to the application's high-quality score and positive user reviews praising the application's effectiveness in completing tasks, resulting in the application's continued use. This is also consistent with previous research, specifically the evaluation of the dietducate application by the general public, in which the majority of respondents found it to be useful, satisfying, and simple to use [15]. Regardless of the quality of the application's content, if it is impractical and difficult for consumers to use, the quality is considered to be poor [25]. User participation can influence the increase in continued use [27].

The reason for the low average subjective quality score (3.74/5) can be attributed to the low score (2.4/5) on the question "will you pay for this app?" Only two users have expressed a willingness to pay for the app in the future. Applications that are still in their infancy or new should not be charged because they build a reputation for the brand and attract more users [28-29]. Gradually, as application users feel appropriate and suited to

their needs. So slowly, applications can be monetized by providing more specialized content, such as protection from advertisements [30]. But before becoming a paid application, it's good to see competitors. If it offers the same features as competitors, but they are free, it is not advised, as you risk losing users [31].

In addition, users assert that the dietducate application contains an excessive number of advertisements. Advertising in free applications is a natural occurrence, given that the application is free to use and the application developer derives revenue from advertising [32]. However, recent studies show that advertisements have hidden costs in terms of energy, network usage, and performance which can affect the assessment of application quality [33]. If users feel annoyed by advertisements, applications can provide options for users to make in-app purchases. so that the app can run without ads [34].

5. Conclusions

Evaluation of the feasibility of the dietducate application using the uMARS method obtained good results or was feasible to use. This is evidenced by the application's good quality rating (4.05 out of 5). The component outcomes are determined by four supporting factors: involvement, functionality, aesthetics, and information. The results of each score are 3.97, 4.03, 4.02, and 4.23. The application is also considered effective in completing the work of nutritionists and is easy to use. However, there are some users who find the application's advertisements annoying, and there are minor bugs that need to be resolved. Users also want application developments such as adding data source information and simplifying dietducate formula calculation options.

Nutritionists can use the dietducate application to be effective in completing their work. Application developers can provide in-app payment options (In-App Purchase) to remove in-app advertisements. fixing minor bugs and adding data source information as well as adding the latest features so that they can be updated and keep up with the times. Research is needed with a more representative sample (probability sampling) so that the research results apply to the entire population.

References

[1]   Kementerian Kesehatan RI Badan Penelitian dan Pengembangan, "Riset Kesehatan Dasar," 2018.

[2]   I. D. N. Supariasa, *Pendidikan dan Konsultasi Gizi*. Jakarta: EGC, 2012.

[3]   T. Tjaronosari and E. Herianandita, *Bahan Ajar Gizi Etika Profesi*. Jakarta: Kementerian Kesehatan RI, 2018.

[4]   Persatuan Ahli Gizi Indonesia, *Buku Naskah Akademik Sistem Pendidikan Tenaga Gizi Bagian I dan II*. Jakarta: Persagi, 2014.

[5]   R. Indira Meutiarani, "EFEKTIFITAS KONSULTASI GIZI TERHADAP PENGETAHUAN, SIKAP, POLA MAKAN DAN TEKANAN DARAH PENDERITA HIPERTENSI DI POLI GIZI RSUD KOTA PADANG PANJANG," Universitas Perintis Indonesia, 2019.

[6]   H. Prasetyo and W. Sutopo, "INDUSTRI 4.0: TELAAH KLASIFIKASI ASPEK DAN ARAH PERKEMBANGAN RISET," *J@ti Undip J. Tek. Ind.*, vol. 13, no. 1, pp. 17–26, Mar. 2018, doi: 10.14710/JATI.13.1.17-26.

[7]   P. : Jurnal, K. Masyarakat, A. Yani, and B. P. Kesehatan, "UTILIZATION OF TECHNOLOGY IN THE HEALTH OF COMMUNITY HEALTH," *Promot.   J. Kesehat. Masy.*, vol. 8, no. 1, pp. 97–103, Jun. 2018, doi: 10.56338/PJKM.V8I1.235.

[8]   Hootsuite & We Are Social, "Digital 2020 Global Digital Overview," 2020. Accessed: Apr. 14, 2020. [Online]. Available: https://datareportal.com/reports/digital-2020-indonesia.

[9]   Statcounter, "Mobile Operating System Market Share Indonesia | StatCounter Global Stats," 2020.

https://gs.statcounter.com/os-market-share/mobile/indonesia (accessed Apr. 14, 2020).

[10] D. Prasetyowati, I. M. Sudana, and S. R. Rahayu, "Health Promotion Innovation in Exclusive Breastfeeding Through Android-based 'Bunda ASI' Application Development to Improve Attitudes and Knowledge," *J. Crit. Rev.*, vol. 7, no. 19, pp. 4827–4834, 2020, Accessed: Mar. 23, 2023. [Online]. Available: https://www.jcreview.com/paper.php?slug=health-promotion-innovation-in-exclucive-breastfeeding-through-android-based-bunda-asi-application-development-to-improve-attitudes-and-knowledge.

[11] M. N. Laila, A. Noviardhi, D. L. Muninggar, M. Jaelani, J. Gizi, and P. Kemenkes Semarang, "EDUKASI GIZI BERBASIS APLIKASI ANDROID MENINGKATKAN PENGETAHUAN EMPAT PILAR PENATALAKSANAAN DIABETES MELITUS PADA PESERTA PROLANIS," *J. Ris. GIZI*, vol. 8, no. 1, pp. 18–24, May 2020, doi: 10.31983/JRG.V8I1.5516.

[12] M. Iqbal and H. Husin, "Perancangan dan Implementasi Konsultasi Gizi Online Berbasis Web," *Prosiding*, vol. 0, no. 0, 2017, Accessed: May 13, 2018. [Online]. Available: https://publikasi.polije.ac.id/index.php/prosiding/article/view/768/508.

[13] Y. Li, J. Ding, Y. Wang, C. Tang, and P. Zhang, "Nutrition-Related Mobile Apps in the China App Store: Assessment of Functionality and Quality," *JMIR Mhealth Uhealth 2019;7(7)e13261 https//mhealth.jmir.org/2019/7/e13261*, vol. 7, no. 7, p. e13261, Jul. 2019, doi: 10.2196/13261.

[14] M. Iqbal, M. R. Permadi, and H. Oktafa, "Dietducate: Intelligent Application Of Nutritional Education To Achieve Ideal Weight By Evidence Based," in *Proceeding of the International Conference on Food and Agriculture*, Dec. 2019, vol. 2, no. 1.

[15] M. Iqbal, S. Riyanto, I. M. A, A. Umami, Y. Yuanta, and A. Febriyatna, "The Development of DIETDUCATE : An Android Based Diet Management Application to Educate Ideal Diet Recommendation," vol. 11, no. 8, pp. 460–466, 2020.

[16] Y. I. Prasetyaningrum, Y. Program, S. Gizi, P. Sarjana, and I. Kesehatan, "Evaluasi kelayakan aplikasi kesehatan berbasis android untuk remaja putri: 'NutriHealth,'" *Ilmu Gizi Indones.*, vol. 4, no. 1, pp. 75–86, Aug. 2020, doi: 10.35842/ILGI.V4I1.181.

[17] N. Lau, A. O'Daffer, J. P. Yi-Frazier, and A. R. Rosenberg, "Popular Evidence-Based Commercial Mental Health Apps: Analysis of Engagement, Functionality, Aesthetics, and Information Quality," *JMIR Mhealth Uhealth 2021;9(7)e29689 https//mhealth.jmir.org/2021/7/e29689*, vol. 9, no. 7, p. e29689, Jul. 2021, doi: 10.2196/29689.

[18] A. D. Beldad and S. M. Hegner, "Expanding the Technology Acceptance Model with the Inclusion of Trust, Social Influence, and Health Valuation to Determine the Predictors of German Users' Willingness to Continue using a Fitness App: A Structural Equation Modeling Approach," *https://doi.org/10.1080/10447318.2017.1403220*, vol. 34, no. 9, pp. 882–893, Sep. 2017, doi: 10.1080/10447318.2017.1403220.

[19] S. R. Stoyanov, L. Hides, D. J. Kavanagh, and H. Wilson, "Development and Validation of the User Version of the Mobile Application Rating Scale (uMARS)," *JMIR Mhealth Uhealth 2016;4(2)e72 https//mhealth.jmir.org/2016/2/e72*, vol. 4, no. 2, p. e5849, Jun. 2016, doi: 10.2196/MHEALTH.5849.

[20] M. Bardus, S. B. van Beurden, J. R. Smith, and C. Abraham, "A review and content analysis of engagement, functionality, aesthetics, information quality, and change techniques in the most popular commercial apps for weight management," *Int. J. Behav. Nutr. Phys. Act.*, vol. 13, no. 1, pp. 1–9, Mar. 2016, doi: 10.1186/S12966-016-0359-9/TABLES/2.

[21] R. Nouri, S. R. N. Kalhori, M. Ghazisaeedi, G. Marchand, and M. Yasini, "Criteria for assessing the quality of mHealth apps: a systematic review," *J. Am. Med. Informatics Assoc.*, vol. 25, no. 8, pp. 1089–1098, Aug. 2018, doi: 10.1093/JAMIA/OCY050.

[22]   Y. Terhorst *et al.*, "Validation of the Mobile Application Rating Scale (MARS)," *PLoS One*, vol. 15, no. 11, Nov. 2020, doi: 10.1371/JOURNAL.PONE.0241480.

[23]   I. Ahmed *et al.*, "Medication Adherence Apps: Review and Content Analysis," *JMIR Mhealth Uhealth 2018;6(3)e62 https//mhealth.jmir.org/2018/3/e62*, vol. 6, no. 3, p. e6432, Mar. 2018, doi: 10.2196/MHEALTH.6432.

[24]   J. Knitza *et al.*, "German Mobile Apps in Rheumatology: Review and Analysis Using the Mobile Application Rating Scale (MARS)," *JMIR Mhealth Uhealth 2019;7(8)e14991 https//mhealth.jmir.org/2019/8/e14991*, vol. 7, no. 8, p. e14991, Aug. 2019, doi: 10.2196/14991.

[25]   S. Y. Kim and E. McFadden, "Using established ux design techniques and visual enhancements to redesign an enterprise mobile app and improve employee productivity and engagement," *Adv. Intell. Syst. Comput.*, vol. 972, pp. 169–176, 2020, doi: 10.1007/978-3-030-19135-1_17/COVER.

[26]   M. Farzandipour, E. Nabovati, M. Heidarzadeh Arani, H. Akbari, R. Sharif, and S. Anvari, "Enhancing Asthma Patients' Self-Management through Smartphone-Based Application: Design, Usability Evaluation, and Educational Intervention," *Appl. Clin. Inform.*, vol. 10, no. 5, pp. 870–878, 2019, doi: 10.1055/S-0039-1700866/ID/JR190095RA-61.

[27]   M. H. W. Ho and H. F. L. Chung, "Customer engagement, customer equity and repurchase intention in mobile apps," *J. Bus. Res.*, vol. 121, pp. 13–21, Dec. 2020, doi: 10.1016/J.JBUSRES.2020.07.046.

[28]   S. Arora, F. Ter Hofstede, and V. Mahajan, "The Implications of Offering Free Versions for the Performance of Paid Mobile Apps," *https://doi.org/10.1509/jm.15.0205*, vol. 81, no. 6, pp. 62–78, Nov. 2017, doi: 10.1509/JM.15.0205.

[29]   L. Stocchi, C. Guerini, and N. Michaelidou, "When Are Apps Worth Paying For?," *J. Advert. Res.*, vol. 57, no. 3, pp. 260–271, Sep. 2017, doi: 10.2501/JAR-2017-035.

[30]   C. Han *et al.*, "Do You Get What You Pay For? Comparing the Privacy Behaviors of Free vs. Paid Apps," *Work. Technol. Consum. Prot. (ConPro 2019), conjunction with 39th IEEE Symp. Secur. Privacy, 23 May 2019, San Fr. CA, USA.*, May 2019, Accessed: Mar. 23, 2023. [Online]. Available: https://dspace.networks.imdea.org/handle/20.500.12761/691.

[31]   J. Van Angeren, G. Vroom, B. T. McCann, K. Podoynitsyna, and F. Langerak, "Optimal Distinctiveness across Revenue Models: Differentiation of Paid and Free Mobile Apps," *https://doi.org/10.5465/AMBPP.2021.11805abstract*, vol. 2021, no. 1, p. 11805, Jul. 2021, doi: 10.5465/AMBPP.2021.11805ABSTRACT.

[32]   W. Meng, R. Ding, S. P. Chung, S. Han, and W. Lee, "The Price of Free: Privacy Leakage in Personalized Mobile In-App Ads," *NDSS*, 2016, doi: 10.14722/ndss.2016.23353.

[33]   J. Gui, D. Li, M. Wan, and W. G. J. Halfond, "Lightweight measurement and estimation of mobile Ad energy consumption," *Proc. - Int. Conf. Softw. Eng.*, pp. 1–7, May 2016, doi: 10.1145/2896967.2896970.

[34]   Taylor, "Free vs Paid Apps: Pros & Cons - AppInstitute," *AppInstitute*, Feb. 11, 2016. https://appinstitute.com/free-paid-apps/ (accessed Mar. 23, 2023).