**Bulletin of Electrical Engineering and Informatics**
Vol. 13, No. 5, October 2024, pp. 3705~3713
ISSN: 2302-9285, DOI: 10.11591/eei.v13i5.8289 

# Systematic review of mobile applications in learning features to support learners living with epilepsy disorders

**Ika Qutsiati Utami[1,2], Wu-Yuin Hwang[2,3], Fathurrahman Syarief[1], Nicholas Juan Kalvin[1]**
[1]Department of Engineering, Faculty of Advanced Technology and Multidiscipline, Universitas Airlangga, Indonesia
[2]Graduate Institute of Network Learning Technology, College of Electrical Engineering and Computer Science, National Central University, ROC, Taiwan
[3]Department of Computer Science and Information Engineering, College of Science and Engineering, National Dong Hwa University, ROC, Taiwan

**Article Info**

***Article history:***

Received Feb 8, 2024
Revised Mar 23, 2024
Accepted Mar 31, 2024

***Keywords:***

Application review
Epilepsy disorders
Health care
Health system
Mobile application rating scale
Mobile apps

**ABSTRACT**

We systematically review mobile health applications in supporting learners living with epilepsy disorders. There are two objectives of this study i.e., assessing the existing epilepsy-related apps and providing information about some features provided by the apps. In total, 18 of 47 mobile apps that meet the final criteria were reviewed using the Mobile Application Rating Scale (MARS). We found that more than half of the apps had below-average quality and most offered only a few distinct functionalities. Six of them were deemed high quality since they met all standard criteria. In terms of self-management features, we identified several important features such as the provision of a seizure calendar (14/18, 78%), report generation (5/18, 28%), adding individual seizure occurrence and causes (9/18, 50%), and emergency alert (6/18, 34%). The majority of the apps included medication tracker (12/18, 67%), expert consultation (6/18, 34%), and educational features (10/18, 56%). Moreover, 40% of included apps have considered self-efficacy features by providing analytical support for seizure frequency, duration, occurrence distribution, and analysis. This research can make in-person support more feasible for epilepsy learners so that it helps families, caregivers, and educators to easily manage the risk and perform continuous aid. This research can also be the basis for developing more patient-centered software for epilepsy management.



***Corresponding Author:***

Ika Qutsiati Utami
Department of Engineering, Faculty of Advanced Technology and Multidiscipline
Universitas Airlangga
Dr. Ir. H. Soekarno Road, Surabaya 60115, East Java, Indonesia
Email: ika.q.utami@ftmm.unair.ac.id

## 1. INTRODUCTION

Epilepsy is a serious clinical phenomenon causing chronic brain disorders [1]-[4]. It involves recurrent seizures and has been associated with false beliefs and conceptions [5]. Globally, people with epileptic disorders exceeded 2.4 million each year, with the highest incidence rates found in developing countries and among them are adults and children [6]-[8]. A study also reported high school learners with epilepsy disorders significantly experience a higher level of negative stigma [9]. Due to poor public knowledge of epilepsy, particularly in an educational setting, most learners suffering from epilepsy drop out of school and difficult to create social interaction [10]. In addition to this fact, schools did not provide formal training for teachers in providing first aid for seizure management of learners with epilepsy. In the way of providing epilepsy management aid and public knowledge, in the past decade, there has been technological

growth in the field of mobile applications, particularly for epilepsy management [11]. Epilepsy mobile apps have several critical features including seizure management, logging the occurrence, medication adherence, and sharing information [12]. However, due to the unregulated market of digital tools, mobile health apps are often of uncertain quality and effectiveness. Commercial app stores only provided star ratings and there is little information on the quality and accuracy of mobile health apps. Star ratings can be useful for indicating user satisfaction and engagement, but they do not enclose necessary information for safety and quality of the apps [13]-[15]. Furthermore, few reviews of mobile applications for epilepsy have highlighted the specific need and usefulness of related apps among learners and millennials people. Whereas, in the time of internet mobile consumption and smartphone access, the highest frequency users of mobile apps are considered millennials. Reportedly, there is incremental growth in terms of smartphone usage from 73% to 95% in 2018 [16]. Previous literature reviews have examined mobile apps for assessing epilepsy related features, but they have predominantly included expensive technologies that may not be available to typical patients [17], [18]. This study aims to tackle these previously mentioned dilemmas by providing information about epilepsy mobile applications for learners with epileptic disorders through a systematic software literature review. There are two objectives in conducting the systematic software literature review of this study. The first is to assess and evaluate the existing epilepsy-related mobile health application (m-health) based on the Google Play Store as a mobile apps database. The second objective is to provide information about some learning features of mobile health relevant to learners with epilepsy disorders in terms of self-management and self-efficacy.

## 2. METHOD

We systematically searched available mobile apps on Android Google Play Store using the following terms: epilepsy, seizure, and epileptic disorder. We selected only Google Play Store because it comprises the overwhelming majority of the market share in this era. Our search process was limited to the search location of Indonesia and Taiwan from February to October 2022. Only specific mobile apps with at least 3-stars, more than 100 times downloaded, and free to download to capture high-quality and accessible epilepsy management apps relevant for learners are covered in this study. After the searching process, the application homepage or landing pages were reviewed to ensure they meet several criteria i.e., using English as the main language, providing features relevant to epileptic disorder people particularly for learners, including epilepsy management tools for seizure tracking and epilepsy emergency management. Apps underwent a total of 3 rounds of screenings. First, they are screened by the name and app description. Free apps with premium features are selected to evaluate the full functionalities of the apps. Secondly, we recruited three independent reviewers from experts to assess the quality of the apps using a common codebook from the MARS framework. Before conducting the MARS evaluation, the reviewers developed a shared understanding of the target group for the apps, discussed each MARS item, and piloted a review of a few apps to ensure an appropriate level of interrater consensus ratings. In the last step, they marked, discussed, and reconciled the review codebook to exclude any errors and validate questionable epilepsy-related apps. Figure 1 shows the flowchart of the systematic search procedure.

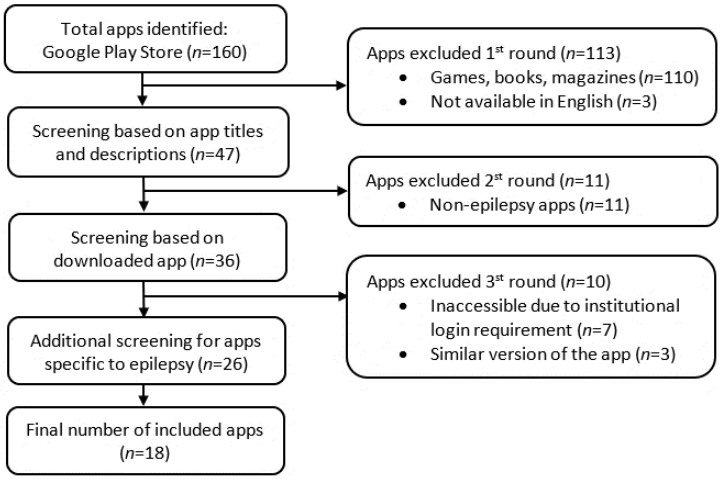


Figure 1. Flow diagram of app screening

## 3. RESULTS AND DISCUSSION

### 3.1. Search result

In the initial stage, we identified 160 potential applications in Google Play Store (see Figure 1). However, they included unrelevant applications such as games, books, or magazine. Searching results containing games or books were excluded for the next stage. During the second round, we conducted screening to ensure the application offered features relevant to epilepsy people based on the app's description. In the third round, we included a total of 26 applications to be downloaded and assessed for eligibility. Some apps were excluded because they did not meet the relevant criteria for epilepsy monitoring. They also have not been downloaded by the people and updated by the developer. In the final search process, only 18 apps were ultimately included for review and analysis.

### 3.2. Descriptive characteristics of included apps

Table 1 provides information about each dimension of MARS with a brief explanation. We evaluated the quality of mobile apps using 5 Likert scales ranging from 1 as inadequate and 5 as excellent quality. In addition, Table 2 provides a brief description of the 18 included apps. All apps were available on Google Play Store and can be downloaded for free. Some of them provide in-app purchasing method. To test the reliability of the MARS questionnaires, Cronbach's alpha test was used for this study. The Cronbach's alpha value of each dimension of MARS (i.e., engagement, functionality, aesthetics, information, and subjective quality of the apps) exceeded 0.90 indicating the items of the scales were reliable. We also evaluated the validity of the scales using expert or senior judgment before spreading the MARS questionnaires. Based on expert judgment, all questionnaire items for MARS were considered valid. Moreover, Inter-rater reliability test was used to measure the level of agreement among three reviewers or judges who volunteered in this study. One of the reviewers has an experience more than twenty years in dealing with epilepsy disorders coming from the family. Furthermore, Kendall's coefficient of concordance for the inter-rater reliability test is 0.79 indicating an acceptable value for agreement. It means the three reviewers applied essentially the same standard when assessing the apps. After the rating process, the result of the evaluation was overseen by the principal investigator, who has received formal education in human-computer interaction (HCI) and focused on researching digital health.

Table 1. MARS dimensions with description

| Dimension | Description |
|---|---|
| App classification. The classification section is used to collect descriptive and technical information about the app. | Application name, rating of the app, rating all versions of the app, the number of ratings, application version, last update, platform, a brief description of the app, application focus, app strategies, target of the user (age), developer/affiliation. |
| App objective quality ratings. The rating scale assesses app quality on four constructs. | a. Engagement assesses the quality of the app in terms of fun, interesting, customizable, and interactive features e.g., alerts, messages, reminders, feedback, and sharing functions.<br>b. Functionality assesses the quality of the app in terms of app functioning, easy-to-learn aspects, navigation, flow logic, and gestural design of the apps.<br>c. Aesthetics assesses the quality of the app in terms of graphic design, visual appearance, color, and stylistic consistency.<br>d. Information assesses the quality of the app in terms of the quality of the information provided by the apps, references, measures, and credible sources. |
| App subjective quality. This scale denotes something that meets people's needs so that they can consider using the apps with minimal disruptions. | Several questions correspond to personal evaluation and opinions regarding the system. |
| App overall quality scores. This scale concludes the total scores of quality and subjective quality dimensions. | App quality mean scores<br>App subjective quality mean scores |

### 3.3. Quality of included apps

Apps were analyzed using the mobile apps rating scale (MARS). The MARS objective and subjective quality mean scores are shown in Table 3. We also provide quality score for each construct in Tables 4 to 7. The importance of self-management in epilepsy disorders is lack of large-scale studies and few that compare the quality of available epilepsy mobile apps. Whereas, mobile-apps for epilepsy self-care and management are promising tools for learners living with epilepsy and epilepsy educators. Mobile applications

with learning features can be an in-person supplement to intensive medical care received by epilepsy patients [19], [20].

Table 2. Epilepsy apps characteristics

| App name | Developer | N-download | Version | Last update | Rating |
|---|---|---|---|---|---|
| Epicalender-seizure diary | MedyCal | 10000+ | 3.1.0 | 09 October 2022 | 4.3 |
| Epilepsy foundation | OpenConcept systems, Inc. | 500+ | 7.33 | 1 June 2022 | 3.6 |
| Epilepsy journal | Olly tree applications | 50000+ | 1.3.37 | 16 October 2022 | 4.1 |
| Epipal | HealthAppy Tech | 10000+ | 4.3.0 | 26 April 2022 | 3.9 |
| Epsy-for seizures and epilepsy | Livanova | 50000+ | 2.24.1 | 11 July 2022 | 4.6 |
| Helpilepsy | Neuroventis | 5000+ | 1.12.0 | 12 October 2022 | 4.0 |
| Nile AI | Nile AI | 50000+ | 4.5.0 | 09 September 2022 | 4.3 |
| Seizure tracker | Seizure tracker LLC | 10000+ | 1.6.7 | 22 August 2022 | 4.4 |
| Simple seizure diary | Luke berry | 10000+ | 1.15.18 | 16 March 2022 | 4.2 |
| Seizure first aide | Afixia | 1000+ | 1.60 | 30 October 2019 | 3.7 |
| Epilepsy ireland: epilepsy man | Epilepsy ireland (epilepsy.ie) | 1000+ | 4.16 | 5 March 2019 | N/A |
| Seer: epilepsy management | Seer medical | 1000+ | 4.0.0.2 | 07 October 2022 | N/A |
| Epilepsy board review q&a | Higher learning technologies Inc | 100+ | 6.29.5586 | 04 August 2022 | N/A |
| Epilepsy help | Dr bindu menon foundations | 1000+ | 1.19 | 04 September 2021 | N/A |
| Epilepsy-cause, diagnosis | Healthy bytes | 500+ | 1.0 | 07 April 2022 | N/A |
| Aura: seizure helper | Com.aura | 100+ | 1.2.2 | 31 October 2022 | N/A |
| Seizure emergency alert | RT tijerina | 500+ | 1.0.8 | 30 June 2022 | N/A |
| Inepilepsy | Insense health | 100+ | 1.1.10 | 08 October 2022 | N/A |

Table 3. The MARS mean scores of included apps

| App name | Engagement | Functionality | Aesthetics | Information | Subjective quality | App quality mean score | Std. Dev. |
|---|---|---|---|---|---|---|---|
| Epicalender-seizure diary | 2.6 | 3.8 | 3.4 | 2.9 | 2.4 | 3.02 | 0.58 |
| Epilepsy foundation | 2.2 | 2.8 | 3.4 | 2.5 | 1.5 | 2.48 | 0.70 |
| Epilepsy journal | 4.2 | 4.8 | 4.7 | 4.6 | 4.2 | 4.50 | 0.28 |
| Epipal | 4.4 | 3.0 | 4.7 | 3.6 | 3.3 | 3.80 | 0.72 |
| Epsy-for seizures and epilepsy | 4.6 | 3.3 | 4.7 | 4.2 | 3.7 | 4.10 | 0.60 |
| Helpilepsy | 4.2 | 4.3 | 5.0 | 4.6 | 3.5 | 4.32 | 0.55 |
| Nile AI | 4.8 | 4.3 | 5.0 | 4.9 | 4.7 | 4.74 | 0.27 |
| Seizure tracker | 2.6 | 2.8 | 3.0 | 2.9 | 1.4 | 2.54 | 0.65 |
| Simple seizure diary | 3.6 | 3.8 | 3.7 | 3.9 | 3.0 | 3.60 | 0.35 |
| Seizure first aide | 2.6 | 2.8 | 3.0 | 2.9 | 1.7 | 2.60 | 0.52 |
| Epilepsy ireland: epilepsy man | 3.8 | 3.8 | 4.0 | 3.9 | 3.2 | 3.74 | 0.31 |
| Seer: epilepsy management | 2.8 | 2.8 | 3.0 | 3.2 | 3.0 | 2.96 | 0.17 |
| Epilepsy board review q&a | 2.6 | 3.0 | 3.4 | 3.0 | 1.7 | 2.74 | 0.65 |
| Epilepsy help | 3.2 | 3.0 | 3.0 | 3.2 | 1.7 | 2.82 | 0.63 |
| Epilepsy-cause, diagnosis | 2.4 | 2.0 | 2.4 | 2.8 | 1.5 | 2.22 | 0.49 |
| Aura: seizure helper | 4.0 | 4.0 | 4.4 | 3.8 | 4.7 | 4.18 | 0.36 |
| Seizure emergency alert | 2.8 | 3.0 | 3.0 | 3.2 | 2.5 | 2.90 | 0.26 |
| Inepilepsy | 4.4 | 4.3 | 4.4 | 4.6 | 3.7 | 4.28 | 0.34 |

Table 4. Engagement quality scores

| App name | Entertainment | Interest | Customisation | Interactivity | Target group |
|---|---|---|---|---|---|
| Epicalender-seizure diary | 2.0 | 2.9 | 2.0 | 2.0 | 4.0 |
| Epilepsy foundation | 2.0 | 1.7 | 2.0 | 2.7 | 2.0 |
| Epilepsy journal | 2.7 | 3.7 | 4.2 | 4.0 | 4.7 |
| Epipal | 3.0 | 3.6 | 3.0 | 3.7 | 4.0 |
| Epsy-for seizures and epilepsy | 4.7 | 3.9 | 3.1 | 4.7 | 4.4 |
| Helpilepsy | 3.3 | 4.1 | 3.4 | 4.3 | 4.3 |
| Nile AI | 4.3 | 4.9 | 3.5 | 4.9 | 4.7 |
| Seizure tracker | 1.5 | 1.7 | 2.0 | 2.5 | 3.3 |
| Simple seizure diary | 2.3 | 3.2 | 3.3 | 3.7 | 4.0 |
| Seizure first aide | 1.3 | 1.3 | 1.3 | 1.7 | 3.0 |
| Epilepsy ireland: epilepsy man | 4.0 | 4.0 | 3.0 | 4.0 | 4.0 |
| Seer: epilepsy management | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Epilepsy board review q&a | 2.0 | 2.0 | 2.0 | 4.0 | 3.0 |
| Epilepsy help | 3.0 | 3.0 | 3.0 | 3.0 | 4.0 |
| Epilepsy-cause, diagnosis | 2.0 | 2.0 | 2.0 | 2.0 | 4.0 |
| Aura: seizure helper | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| Seizure emergency alert | 2.0 | 2.0 | 2.0 | 4.0 | 4.0 |
| Inepilepsy | 4.0 | 4.0 | 5.0 | 4.0 | 5.0 |

All apps included in the evaluation lists were reviewed in terms of engagement, functionality, aesthetics, information, and subjective quality. We found that more than half of the apps had below-average quality and most offered only a few distinct functionalities. However, six of 18 included epilepsy mobile apps (i.e., Epilepsy Journal, Epsy-For Seizures and Epilepsy, Helpilepsy, Nile AI, Aura: Seizure Helper, and Inepilepsy) were deemed high quality. These six apps had great variability in engagement, functionality, aesthetics, and information so that they meet all MARS standard criteria. Nile AI is the most qualified app among others in providing learning features and important information about epilepsy. It also becomes the top two apps besides Helpilepsy in meeting the standard aesthetics of application features. With respect to the functionality of the apps, Epilepsy Journal has been considered the most highly-rated app since this application provides all required functions for epilepsy disorders in terms of self-management learning features and self-efficacy learning features. Epilepsy Journal also provides customization features and in-app purchases. It means learners living with epilepsy can buy additional content or services within the app for customization and personalization.

Table 5. Functionality quality scores

| App name | Performance | Ease of use | Navigation | Gestural design |
|---|---|---|---|---|
| Epicalender-seizure diary | 4.0 | 4.5 | 4.1 | 3.1 |
| Epilepsy foundation | 2.3 | 2.3 | 2.7 | 3.8 |
| Epilepsy journal | 3.8 | 4.6 | 4.2 | 4.3 |
| Epipal | 2.5 | 2.5 | 3.3 | 2.7 |
| Epsy-for seizures and epilepsy | 3.8 | 3.0 | 3.5 | 3.8 |
| Helpilepsy | 3.8 | 3.7 | 4.1 | 4.2 |
| Nile AI | 3.7 | 4.0 | 4.3 | 4.3 |
| Seizure tracker | 4.0 | 3.2 | 2.7 | 2.6 |
| Simple seizure diary | 3.9 | 3.9 | 4.3 | 4.0 |
| Seizure first aide | 2.7 | 3.0 | 2.3 | 1.7 |
| Epilepsy ireland: epilepsy man | 4.0 | 4.0 | 4.0 | 3.0 |
| Seer: epilepsy management | 3.0 | 2.0 | 3.0 | 3.0 |
| Epilepsy board review q&a | 3.0 | 3.0 | 3.0 | 3.0 |
| Epilepsy help | 3.0 | 3.0 | 3.0 | 3.0 |
| Epilepsy-cause, diagnosis | 2.0 | 2.0 | 2.0 | 2.0 |
| Aura: seizure helper | 4.0 | 4.0 | 4.0 | 4.0 |
| Seizure emergency alert | 3.0 | 3.0 | 3.0 | 3.0 |
| Inepilepsy | 4.0 | 4.0 | 5.0 | 4.0 |

Table 6. Aesthetics quality scores

| App name | Layout | Graphics | Visual appeal |
|---|---|---|---|
| Epicalender-seizure diary | 3.0 | 3.2 | 3.2 |
| Epilepsy foundation | 2.9 | 3.3 | 2.5 |
| Epilepsy journal | 3.9 | 4.2 | 3.3 |
| Epipal | 3.7 | 4.1 | 4.4 |
| Epsy-for seizures and epilepsy | 4.3 | 4.5 | 4.5 |
| Helpilepsy | 4.8 | 4.4 | 4.5 |
| Nile AI | 4.9 | 4.5 | 4.3 |
| Seizure tracker | 2.8 | 3.0 | 2.5 |
| Simple seizure diary | 3.2 | 3.3 | 3.3 |
| Seizure first aide | 3.0 | 2.3 | 2.0 |
| Epilepsy ireland: epilepsy man | 4.0 | 4.0 | 4.0 |
| Seer: epilepsy management | 3.0 | 3.0 | 3.0 |
| Epilepsy board review q&a | 4.0 | 3.0 | 3.0 |
| Epilepsy help | 3.0 | 3.0 | 3.0 |
| Epilepsy-cause, diagnosis | 3.0 | 2.0 | 2.0 |
| Aura: seizure helper | 4.0 | 4.0 | 5.0 |
| Seizure emergency alert | 3.0 | 3.0 | 3.0 |
| Inepilepsy | 5.0 | 4.0 | 4.0 |

### 3.4. The functionality of included apps

Almost 50% of the final included apps have some type of engagement such as interactive features including epilepsy alerts, messages, reminders, feedback, and sharing functions (see Tables 8 and 9). Visualization for comparing the objective and subjective quality in terms of 5 variables of MARS are shown in Figure 2.

Table 7. Information quality scores

| App name | Accuracy | Goals | Information quality | Information quantity | Visual information | Credibility | Evidence base |
|---|---|---|---|---|---|---|---|
| Epicalender-seizure diary | 4.3 | 4.2 | 3.3 | 2.3 | 1.3 | 3.0 | 3.0 |
| Epilepsy foundation | 2.3 | 2.0 | 3.0 | 3.0 | 2.0 | 3.0 | 2.0 |
| Epilepsy journal | 5.0 | 4.6 | 4.0 | 4.3 | 4.7 | 3.0 | 3.3 |
| Epipal | 4.5 | 4.2 | 2.7 | 3.0 | 3.0 | 3.0 | 3.0 |
| Epsy-for seizures and epilepsy | 4.9 | 4.7 | 4.0 | 4.0 | 4.1 | 3.0 | 3.0 |
| Helpilepsy | 4.9 | 4.5 | 4.0 | 4.0 | 4.4 | 3.3 | 3.3 |
| Nile AI | 4.8 | 4.7 | 4.3 | 4.3 | 3.3 | 3.7 | 3.7 |
| Seizure tracker | 3.8 | 3.5 | 2.5 | 2.0 | 2.5 | 3.0 | 3.0 |
| Simple seizure diary | 4.5 | 4.3 | 3.7 | 3.7 | 3.2 | 3.3 | 3.0 |
| Seizure first aide | 3.8 | 3.9 | 3.0 | 2.0 | 3.0 | 3.0 | 3.0 |
| Epilepsy ireland: epilepsy man | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 3.0 | 4.0 |
| Seer: epilepsy management | 2.0 | 4.0 | 4.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Epilepsy board review q&a | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Epilepsy help | 3.0 | 4.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Epilepsy-cause, diagnosis | 3.0 | 3.0 | 4.0 | 3.0 | 2.0 | 2.0 | 2.0 |
| Aura: seizure helper | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 3.0 | 3.0 |
| Seizure emergency alert | 3.0 | 4.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Inepilepsy | 4.0 | 5.0 | 5.0 | 5.0 | 5.0 | 4.0 | 4.0 |

Table 8. Epilepsy application learning features for self-management

| Application name | Seizure calendar | Generating Report | Adding individual seizure cause | Emergency alert | Medication tracker | Expert Consultation | Update user profile | Educational features | In-app purchase | Customization |
|---|---|---|---|---|---|---|---|---|---|---|
| Epicalender-seizure diary | ✓ | ✓ | ✓ | ⦸ | ✓ | ✓ | ✓ | ⦸ | ✓ | ⦸ |
| Epilepsy foundation | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ✓ | ✓ | ⦸ | ⦸ |
| Epilepsy journal | ✓ | ✓ | ✓ | ⦸ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Epipal | ✓ | ⦸ | ⦸ | ⦸ | ✓ | ⦸ | ✓ | ⦸ | ⦸ | ⦸ |
| Epsy-for seizures and epilepsy | ✓ | ✓ | ✓ | ⦸ | ✓ | ⦸ | ✓ | ✓ | ⦸ | ⦸ |
| Helpilepsy | ✓ | ✓ | ✓ | ⦸ | ✓ | ✓ | ✓ | ✓ | ⦸ | ✓ |
| Nile AI | ✓ | ✓ | ✓ | ⦸ | ✓ | ✓ | ✓ | ⦸ | ⦸ | ✓ |
| Seizure tracker | ✓ | ⦸ | ⦸ | ⦸ | ✓ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ |
| Simple seizure diary | ✓ | ⦸ | ✓ | ⦸ | ✓ | ⦸ | ✓ | ⦸ | ⦸ | ✓ |
| Seizure first aide | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ |
| Epilepsy ireland: epilepsy man | ✓ | ⦸ | ⦸ | ✓ | ✓ | ✓ | ⦸ | ⦸ | ⦸ | ⦸ |
| Seer: epilepsy management | ✓ | ⦸ | ⦸ | ✓ | ✓ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ |
| Epilepsy board review q&a | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ✓ | ⦸ | ⦸ |
| Epilepsy help | ✓ | ⦸ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ⦸ | ⦸ |
| Epilepsy-cause, diagnosis | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ✓ | ⦸ | ⦸ |
| Aura: seizure helper | ✓ | ⦸ | ✓ | ✓ | ⦸ | ⦸ | ⦸ | ✓ | ⦸ | ⦸ |
| Seizure emergency alert | ✓ | ⦸ |  | ✓ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ✓ |
| Inepilepsy | ✓ | ⦸ | ✓ | ✓ | ✓ | ⦸ | ✓ | ⦸ | ⦸ | ✓ |

Table 9. Epilepsy application learning features for self-efficacy

| Application name | Analytical support: seizure frequency | Analytical support: seizure duration | Analytical support: seizure distribution | Analytical support: seizure types | Analytical support: trigger types | Artificial intelligence support | More detailed Seizure analysis |
|---|---|---|---|---|---|---|---|
| Epicalender-seizure diary | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ |
| Epilepsy foundation | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ |
| Epilepsy journal | ✓ | ✓ | ✓ | ✓ | ✓ | ⦸ | ⦸ |
| Epipal | ✓ | ✓ | ⦸ | ✓ | ✓ | ⦸ | ⦸ |
| Epsy-for seizures and epilepsy | ✓ | ⦸ | ⦸ | ✓ | ✓ | ⦸ | ⦸ |
| Helpilepsy | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ⦸ |
| Nile AI | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ⦸ |
| Seizure tracker | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ |
| Simple seizure diary | ✓ | ✓ | ✓ | ✓ | ✓ | ⦸ | ✓ |
| Seizure first aide | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ |
| Epilepsy ireland: epilepsy man | ✓ | ✓ | ✓ | ⦸ | ⦸ | ⦸ | ⦸ |
| Seer: epilepsy management | ⦸ | ⦸ | ⦸ | ✓ | ✓ | ⦸ | ⦸ |
| Epilepsy board review q&a | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ |
| Epilepsy help | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ |
| Epilepsy-cause, diagnosis | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ |
| Aura: seizure helper | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ |
| Seizure emergency alert | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ |
| Inepilepsy | ⦸ | ⦸ | ⦸ | ⦸ | ⦸ | ✓ | ⦸ |

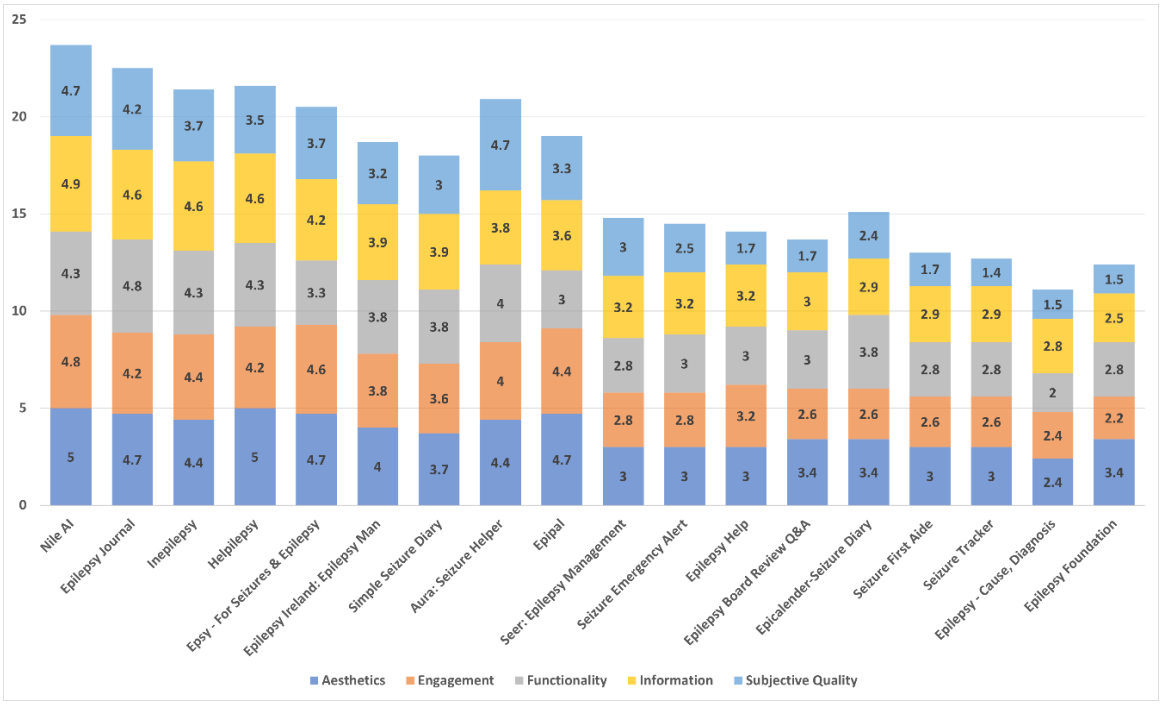


Figure 2. Quality comparison of included apps

Younger people as learners prefer more interactive and automatic features from technology to allow easy monitoring directly from a device. Engagement and aesthetic features have long been considered important usability functions for young learners in particularly mobile health apps [21]-[24]. With respect to self-management learning features, this study identified several important features such as the provision of seizure calendar (14/18, 78%), report generation (5/18, 28%), adding individual seizure occurrence and causes (9/18, 50%), and emergency alert (6/18, 34%). Furthermore, the majority of apps allowed for the inclusion of a medication tracker (12/18, 67%), expert consultation (6/18, 34%), and educational features (10/18, 56%) such as interactive content, tutorials, gamification, and question-answer session. Educational features in this regard also include essential information about epilepsy disorders. Additionally, most of the apps also provide customization functions and enable updates for user profile information. Regarding other important learning features supporting self-efficacy, mobile apps to promote analytical support may help personalize a selection of medical therapies and motivate positive behavioral change to reduce symptom burden. Almost 40% of included apps have considered analytical support for seizure frequency, duration, and occurrence distribution. Most of them also provided analytical support for analyzing seizure types and trigger types. Additionally, several apps are supported by artificial intelligence (AI) and analytical functions for seizure analysis. Three apps (i.e., Helpilepsy, Nile AI, and Inepilepsy) provide potential benefits using AI support to train patients-related data and gain some insight from the data. It can play a significant and potential role in discovering sensible and meaningful patterns from patients' related data such as for better seizure detection, epilepsy lateralization, differentiating seizure states, and localization [24], [25].

## 4. CONCLUSION

In this study, we systematically reviewed and evaluated 18 final included mobile apps for epilepsy management using MARS. In total, six of 18 included epilepsy mobile apps (i.e., Epilepsy Journal, Epsy-For Seizures and Epilepsy, Helpilepsy, Nile AI, Aura: Seizure Helper, and Inepilepsy) were deemed high quality. Further, only one app was found with comprehensive learning features i.e., self-management and self-efficacy that were specifically relevant to the learners with epilepsy. Most importantly, our results suggest that existing epilepsy apps should widely support both self-management and self-efficacy. This may, in turn, have broader implications for promoting the uptake of self-management strategies for learners living with epilepsy disorders. In addition, mobile health is commonly associated with user's existential experiences. In this case, healthcare providers should acknowledge and consider the quality assessment of proposed applications thoroughly. However, this study is not without limitations. We systematically searched the existing mobile apps from a location in Indonesia and Taiwan. Furthermore, we only considered the

Google Play Store database for searching relevant epilepsy mobile apps. Whereas, the search result of the systematic literature review is sensitive to the database and the location of the search. On the other hand, ongoing review and future studies should take into account the new and emerging apps with improved functionality, evidence-based content, and app usability, specifically for learners living with epilepsy and epilepsy educators. Further, additional effectiveness studies that review the impact that these tools can have on epilepsy management and outcomes are also warranted. Additional app development or supplemental functionality specific to the emerging adult population should be considered by developers and health professionals.

## REFERENCES


[1] Y. M. T. Siahaan, R. J. Ketaren, V. Hartoyo, and T. I. Hariyanto, "Epilepsy and the risk of severe coronavirus disease 2019 outcomes: A systematic review, meta-analysis, and meta-regression," *Epilepsy & Behavior*, vol. 125, p. 108437, Dec. 2021, doi: 10.1016/j.yebeh.2021.108437.

[2] S. Kwok, J. Engle, and A. N. Datta, "Resilience of adolescents and teenagers with self-limited and genetic-generalized epilepsy during the COVID-19 pandemic," *Epilepsy & Behavior Reports*, vol. 17, p. 100520, 2022, doi: 10.1016/j.ebr.2021.100520.

[3] H. Tu *et al.*, "The association between illness perception and quality of life among Chinese adults with epilepsy: The mediating role of coping style," *Epilepsy & Behavior*, vol. 130, p. 108677, May 2022, doi: 10.1016/j.yebeh.2022.108677.

[4] W. T. Kerr *et al.*, "Epilepsy, dissociative seizures, and mixed: Associations with time to video-EEG," *Seizure*, vol. 86, pp. 116–122, Mar. 2021, doi: 10.1016/j.seizure.2021.02.002.

[5] L. G. da Silva *et al.*, "Beliefs and attitudes towards child epilepsy: A structural equation model," *Seizure*, vol. 84, pp. 53–59, Jan. 2021, doi: 10.1016/j.seizure.2020.11.020.

[6] S. Asnakew *et al.*, "Knowledge and attitude of the community towards epilepsy in Northwest Ethiopia: A huge gap on knowledge and attitude of the community," *Epilepsy & Behavior Reports*, vol. 15, p. 100422, 2021, doi: 10.1016/j.ebr.2020.100422.

[7] C. O. Akosile, J. U. Anomneze, E. C. Okoye, B. O. A. Adegoke, R. Uwakwe, and E. Okeke, "Quality of life, fatigue and seizure severity in people living with epilepsy in a selected Nigerian population," *Seizure*, vol. 84, pp. 1–5, Jan. 2021, doi: 10.1016/j.seizure.2020.10.029.

[8] M. Davoudi, T. Lundgren, M. Jansson-Fröjmark, Z. Saeedipour, and F. Badinlou, "The Psychological Flexibility in Epilepsy Questionnaire (PFEQ): Psychometric properties of the Persian version," *Epilepsy & Behavior*, vol. 130, p. 108672, May 2022, doi: 10.1016/j.yebeh.2022.108672.

[9] A. Budikayanti *et al.*, "The stigma paradox: Perception of quality-of-life in people with epilepsy among themselves, the family, and the general population in Indonesian urban areas," *Epilepsy Research*, vol. 183, p. 106938, Jul. 2022, doi: 10.1016/j.eplepsyres.2022.106938.

[10] R. A. Horváth *et al.*, "Epilepsy is overrepresented among young people who died from COVID-19: Analysis of nationwide mortality data in Hungary," *Seizure*, vol. 94, pp. 136–141, Jan. 2022, doi: 10.1016/j.seizure.2021.11.013.

[11] C. Jory, R. Shankar, D. Coker, B. McLean, J. Hanna, and C. Newman, "Safe and sound? A systematic literature review of seizure detection methods for personal use," *Seizure*, vol. 36, pp. 4–15, 2016, doi: 10.1016/j.seizure.2016.01.013.

[12] Z. Biskupiak, V. V. Ha, A. Rohaj, and G. Bulaj, "Digital Therapeutics for Improving Effectiveness of Pharmaceutical Drugs and Biological Products: Preclinical and Clinical Studies Supporting Development of Drug + Digital Combination Therapies for Chronic Diseases," *Journal of Clinical Medicine*, vol. 13, no. 2, pp. 403–403, Jan. 2024, doi: /10.3390/jcm13020403.

[13] L. S. Olsen, J. M. Nielsen, C. Simonÿ, T. W. Kjær, and M. Beck, "Wearables in real life: A qualitative study of experiences of people with epilepsy who use home seizure monitoring devices," *Epilepsy & Behavior*, vol. 125, p. 108398, Dec. 2021, doi: 10.1016/j.yebeh.2021.108398.

[14] M. K. Tschamper, A. K. Wahl, Å. Hermansen, R. Jakobsen, and M. H. Larsen, "Parents of children with epilepsy: Characteristics associated with high and low levels of health literacy," *Epilepsy & Behavior*, vol. 130, p. 108658, May 2022, doi: 10.1016/j.yebeh.2022.108658.

[15] J. Ben *et al.*, "Employment status as a major determinant for lower physical activity of patients with epilepsy: A case-control study," *Epilepsy & Behavior*, vol. 115, p. 107655, Feb. 2021, doi: 10.1016/j.yebeh.2020.107655.

[16] M. R. Turchioe, V. Jimenez, S. Isaac, M. Alshalabi, D. Slotwiner, and R. M. Creber, "Review of mobile applications for the detection and management of atrial fibrillation," *Heart Rhythm O2*, vol. 1, no. 1, pp. 35–43, Apr. 2020, doi: 10.1016/j.hroo.2020.02.005.

[17] D. J. Lu, M. Girgis, J. M. David, E. M. Chung, K. M. Atkins, and M. Kamrava, "Evaluation of Mobile Health Applications to Track Patient-Reported Outcomes for Oncology Patients: A Systematic Review," *Advances in Radiation Oncology*, vol. 6, no. 1, p. 100576, Jan. 2021, doi: 10.1016/j.adro.2020.09.016.

[18] A. E. Roberts, T. A. Davenport, T. Wong, H.-W. Moon, I. B. Hickie, and H. M. LaMonica, "Evaluating the quality and safety of health-related apps and e-tools: Adapting the Mobile App Rating Scale and developing a quality assurance protocol," *Internet Interventions*, vol. 24, p. 100379, Apr. 2021, doi: 10.1016/j.invent.2021.100379.

[19] M. S. Farooq, A. Zulfiqar, and S. Riaz, "Epileptic Seizure Detection Using Machine Learning: Taxonomy, Opportunities, and Challenges," *Diagnostics*, vol. 13, no. 6, p. 1058, Mar. 2023, doi: 10.3390/diagnostics13061058.

[20] P. Afra *et al.*, "Mobile Software as a Medical Device (SaMD) for the Treatment of Epilepsy: Development of Digital Therapeutics Comprising Behavioral and Music-Based Interventions for Neurological Disorders," *Frontiers in Human Neuroscience*, vol. 12, May 2018, doi: 10.3389/fnhum.2018.00171.

[21] O. Al-Shamaileh and A. Sutcliffe, "Why people choose Apps: An evaluation of the ecology and user experience of mobile applications," *International Journal of Human-Computer Studies*, vol. 170, p. 102965, Feb. 2023, doi: 10.1016/j.ijhcs.2022.102965.

[22] J. Schindler-Ruwisch and A. Peters, "Mobile applications for emerging adults transitioning to independent diabetes monitoring," *Informatics for Health and Social Care*, vol. 46, no. 1, pp. 56–67, Mar. 2021, doi: 10.1080/17538157.2020.1837839.

[23] I. Q. Utami and F. Ramdani, "GEMAR: web-based GIS for emergency management and ambulance routing," *Informatics for Health and Social Care*, vol. 47, no. 2, pp. 123–131, Apr. 2022, doi: 10.1080/17538157.2021.1948856.

[24] M. K. Siddiqui, R. Morales-Menendez, X. Huang, and N. Hussain, "A review of epileptic seizure detection using machine learning classifiers," *Brain Informatics*, vol. 7, no. 1, p. 5, Dec. 2020, doi: 10.1186/s40708-020-00105-1.

[25] M. Safeer V S, P. Gupta, S. Behl, D. Bansal, and J. K. Sahu, "Mobile health applications for epilepsy in Indian app stores: A systematic review and content analysis using the mobile app rating scale," *Epilepsy Research*, vol. 201, p. 107331, Mar. 2024, doi: 10.1016/j.eplepsyres.2024.107331.

## BIOGRAPHIES OF AUTHORS

**Ika Qutsiati Utami** is a Ph.D. student at the Graduate Institute of Network Learning Technology, National Central University, Taiwan, ROC. Her research interests are in the areas of human-computer interaction and AI in education. She is also a junior lecturer in the Data Science Technology Study Program from the Engineering Department, Faculty of Advanced Technology and Multidiscipline, Universitas Airlanpgga, Indonesia. She can be contacted at email: ika.q.utami@ftmm.unair.ac.id.

**Wu-Yuin Hwang** is a professor affiliated with both the Department of Computer Science and Information Engineering, College of Science and Engineering, National Dong Hwa University, Taiwan, and the Institute of Network Learning Technology, National Central University, Taiwan. His current research interests are related to the integration of IOT, AI, and multimedia sensors of mobile devices for learning and interactions among humans and all things in AR contexts like smart buildings and campuses. He can be contacted at email: wyhwang1206@gmail.com.

**Fathurrahman Syarief** is a student at the Data Science Technology Study Program from the Department of Engineering, Faculty of Advanced Technology and Multidiscipline, Universitas Airlangga, Indonesia. He can be contacted at email: fathurrahman.syarief-2020@ftmm.unair.ac.id.

**Nicholas Juan Kalvin** is a student at the Data Science Technology Study Program from the Engineering Department, Faculty of Advanced Technology and Multidiscipline, Universitas Airlangga, Indonesia. He can be contacted at email: nicholas.juan.kalvin-2020@ftmm.unair.ac.id.