

Assessment of mHealth Solutions Applied to Fall Detection for the Elderly

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Abstract. Mobile Health has been increasingly present in healthcare due to the wide availability of applications for smartphones, however, robust assessment methods must be considered, seeking to provide evidence for clinical practice and mHealth solutions. This research presents the assessment of applications aimed at detecting and preventing falls for the elderly, available for Android and IOS, through the Mobile App Rating Scale. Based on the results presented, it can be concluded that the fall detection and prevention applications for the elderly available for Android and IOS showed good quality after rigorous evaluation.

Keywords. Digital Health. Mobile Health. Prevention. IoT. Falls. Assessment.

1. Introduction

According to the World Health Organization (WHO), falls represent the second leading cause of accidental or unintentional deaths in the world (traffic accidents are the main cause in this group), resulting in approximately 650,000 deaths, and, of these, 80% in low-and middle-income countries. In this context, individuals over 60 years of age are the most susceptible to fatal falls (424,000 deaths), suggesting that falls for the elderly have become a public health problem[16; 17].

While many falls are not fatal, approximately 38 million of those that occur annually are severe enough to result in hospitalization. The costs of injuries related to falls are substantial, as, among the population of 65 years old or over, the average cost per injury can range from US\$1,049.00 to US\$3,611.00 in countries such as Australia and Finland, respectively[16].

Due to the increased use of the internet through smartphones and wearable devices (such as smart watches and bracelets), monitoring strategies are becoming increasingly popular through alerts, for example, in addition to contributing to training actions related to the treatment and prevention of diseases, and improving access to health services, clinical diagnosis and treatment adherence[6].

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In this context, mHealth solutions have been developed for the detection and prevention of falls, through research using cell phone sensors (gyroscope and accelerometer), Machine Learning, among other technologies[10; 13].

Despite mHealth's advances[11] and the development of applications for the detection and prevention of falls aimed at the elderly population in recent years, such solutions rarely present a scientific mHealth assessment, and when assessment is performed, the instruments used are not specific to mHealth[7]. Therefore, there are gaps to be clarified for a broader adoption in clinical practice and based on scientific evidence[1].

Thus, the aim of this paper is to answer the question: Are the free applications currently available for the Android and IOS operating systems and aimed at detecting and preventing falls for the elderly, having good quality after rigorous scientific mHealth evaluation? Thus, the objective is to present an evaluation of mHealth solutions for the detection and prevention of falls for the elderly.

2. Methods

Study on the assessment of applications for the detection and prevention of falls for the elderly, which started with the search strategy carried out by 2 researchers independently, being followed by the description of the applications, categorization and analysis of features. The last step presented the assessment of applications by MARS, ending with the statistical analysis.

The search strategy was carried out through a search in the digital distribution service of Google (Google Play) and Apple (App Store), as they are the platforms associated with the most used operating systems in the world for mobile applications (Android and iOS, respectively).

The assessment was conducted in the 2nd semester of 2020 and 1st semester of 2021 and used the following keywords and synonyms: "Fall" and "Elderly". Applications made available free of charge on the digital distribution service offered by Google (Google Play) and by Apple (App Store), and that presented the description provided by the developer, to identify the purpose of the study and the target population, were included in the study.

Applications with functionality presented in Portuguese, English and Spanish were also included, and applications with inoperable features, paid items (and not provided by the developer), and those that do not directly presented information on the detection and prevention of falls were excluded. The application screening and eligibility process is shown in figure 1.

In evaluating the applications, a scale focused on mHealth was used, the Mobile Application Rating Scale (MARS)[5], which is a questionnaire that measures the quality of health applications based on 23 questions organized into 4 objective categories (engagement, functionality, aesthetics and information quality) and 1 subjective category. Each question is rated on a 5-point scale (1-inadequate, 2-poor, 3-acceptable, 4-good, 5-excellent)[14].

The assessment of the apps was presented by the average, used as a measure of central tendency, and the standard deviation to quantify its variability. To identify the correlation between the categories (A, B, C, D, and E subjective) and the Final Score, the Pearson's correlation coefficient test was used. For all statistical analysis, a

significance level of 5% was considered. All statistical analysis were performed using Jamovi software (The Jamovi Project, Sydney, Australia) version 1.6.3.

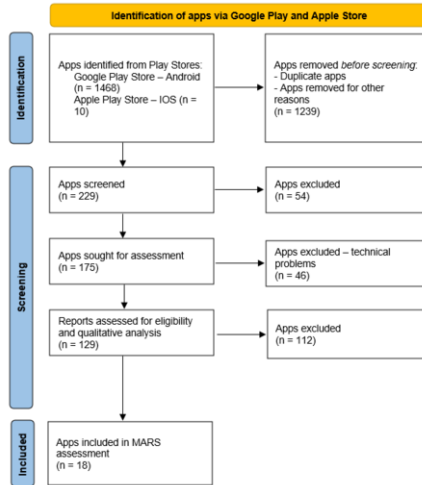


Figure 1. Flowchart of app selection

3. Results and Discussion

The assessment resulted in 18 apps that were rated by the MARS scale. The results indicated a positive correlation between the Final Score and Engagement ($r=0.872$; $R^2=76.0\%$; $p<0.001$); Functionality ($r=0.498$; $R^2=24.8\%$; $p=0.042$); Aesthetics ($r=0.909$; $R^2=82.6\%$; $p<0.001$); Information ($r=0.838$; $R^2=70.2\%$; $p<0.001$); Subjective ($r=0.953$; $R^2=90.8\%$; $p<0.001$).

Table 1 presents the main features of the apps. It is important to note that 4 applications were compatible with wearables (smartwatch), that is, the development of applications for wearable devices for monitoring falls is still rarely used. In the analysis of the use of sensors, applications aimed at health education actions for patients did not present sensors, however, all applications that detect falls use the accelerometer sensor, which is the main resource used to detect the vibrations associated with falls.

In addition to these features, some applications make use of the gyroscope sensor that together with the accelerometer sensor can improve the accuracy of the fall detection. The use of the GPS sensor by some applications contributes to the user's physical monitoring, thus, regardless of geographic location, GPS makes it possible to record the place where the fall occurs, which can be used as an alert to emergency contacts and immediate help.

The assessment was performed using the MARS scale shown in Table 2, which is organized in descending order of the Final Score, with general average ranging from 4.75 (± 0.25) to 1.86 (± 0.69).

MARS has been widely used since 2015[9], and to present, the literature has more than 100 related publications (www.pubmed.com). This instrument has become widespread as can be seen in a review of urinary incontinence management applications[2]. Both studies[2; 9] suggest the importance of using scales such as MARS in the assessment stage, seeking to improve mHealth solutions.

Table 1. Sample characteristics

APP	Link	Language	OS	COMPATIBILITY	FREWARE	CATEGORY	SUBCATEGORY	ACCESSORIES	SENSORS	ML
1	https://apps.apple.com/br/app/fall/safety-personal-alerts/id870864283	English	Android / IOS	Requires Android 5.0 or higher / iOS 12.0 and watchOS 5.0 or higher.	No	Patient Centered	Health Tracking	Smartphone / Smartwatch	Accelerometer/ Gyroscope / GPS	Yes
2	https://apps.apple.com/us/app/fall/safety-home-personal-alerts/id1097177984	English	IOS	iOS 9.0 and watchOS 2.0 or higher	No	Patient Centered	Health Tracking	Smartphone / Smartwatch	Accelerometer/ Gyroscope / GPS	Yes
3	https://play.google.com/store/apps/details?id=com.chickincaim.fall&hl=pt_BR&gl=US	English	Android	Android 5.0 or higher	No	Patient Centered	Health Tracking	Smartphone / Smartwatch	Accelerometer/ Gyroscope / GPS	-
4	https://play.google.com/store/apps/details?id=com.caringcompany.mai&hl=pt-br&gl=US	English	Android / IOS	Android 5.0 or higher / iOS 13.0 or higher	No	Patient Centered	Health Tracking	Smartphone	Accelerometer/ GPS	Yes
5	https://play.google.com/store/apps/details?id=com.tidyware.safetysafety.pro&hl=en_US&gl=US	English	Android / IOS	Android 5.0 or higher / iOS 13.0 or higher	No	Patient Centered	Health Tracking	Smartphone	Accelerometer/ Gyroscope / GPS	-
6	https://apps.apple.com/pt/app/SaiveVivo&hl=fr_CH	Portuguese	Android	Android 2.3 or higher	Yes	Educational	Patient Education	Smartphone	No need	No
7	https://play.google.com/store/apps/details?id=com.hcupontofall&hl=pt_BR&gl=US	English	Android / IOS	Android 5.0 or higher / iOS 10.3 or higher	Yes	Educational	Patient Education	Smartphone	No need	No
8	https://play.google.com/store/apps/details?id=com.healthhappy.sci&hl=pt_BR&gl=US	English	Android	Android 5.0 or higher	Yes	Patient Centered	Health Tracking	Smartphone	Accelerometer/ GPS	-
9	https://play.google.com/store/apps/details?id=com.SaiveVivo&hl=fr_CH	Portuguese	Android	Android 4.4 or higher	Yes	Educational	Patient Education	Smartphone	No need	No
10	https://play.google.com/store/apps/details?id=com.jump.falls&hl=pt_BR&gl=US	English	Android / IOS	Android 4.1 or higher / iOS 10.0 or higher	Yes	Educational	Patient Education	Smartphone	Accelerometer/ Gyroscope	No
11	https://play.google.com/store/apps/details?id=com.m.fall.detection	English	Android	Android 4.1 or higher	Yes	Patient Centered	Health Tracking	Smartphone	Accelerometer	Yes
12	https://play.google.com/store/apps/details?id=com.m.fall.detection	English	Android	Android 4.1 or higher	Yes	Patient Centered	Health Tracking	Smartphone	Accelerometer	--
13	https://apps.apple.com/us/app/Alarm-frees/id284728433	English	IOS	iOS 12.0 or higher	Yes	Patient Centered	Health Tracking	Smartphone	Accelerometer/ Gyroscope / GPS	No
14	https://play.google.com/store/apps/details?id=up.primovetor.at_safekham1.3.freefall	English	Android	Android 1.5 or higher	Yes	Patient Centered	Health Tracking	Smartphone/ Smartwatch	Accelerometer/ Gyroscope	-
15	https://apps.apple.com/pt/app/care24/id1152041483	English	IOS	iOS 12.0 or higher	Yes	Patient Centered	Health Tracking	Smartphone	Accelerometer/ GPS	No
16	https://play.google.com/store/apps/details?id=com.astruth.falldetect	English	Android	Android 7.0 or higher	Yes	Patient Centered	Health Tracking	Smartphone	Accelerometer/ Gyroscope / GPS	Yes
17	https://play.google.com/store/apps/details?id=falldetectionv2.ace	English	Android	Android 5.1 or higher	Yes	Patient Centered	Health Tracking	Smartphone	Accelerometer/ Gyroscope	--
18	https://play.google.com/store/apps/details?id=com.gimovation.gamofalls.live	English	Android	Android 5.0 or higher	Yes	Patient Centered	Patient Education	Smartphone	-	No

OS – Operating System / ML – Machine Learning

Considering the MARS domains, category A, which covers issues related to engagement, was the category with the lowest overall average in our study (3.43±0.93). Engagement strategies such as gamification were not relevant to the context of falling for the elderly, however, such techniques have shown good results in mHealth solutions related to Nutrition in children and adolescents[12].

In category B related to features, there was a higher overall average (4.24±0.45), due to the easy use of the applications, simple and objective design, and few gaps related to navigation.

In category C (3.58±0.36), which evaluates the proportion of components in the interface, graphic quality of icons and aesthetic appeal, for example, the average was possibly influenced by applications that did not present a visually attractive interface (such as buttons in irregular positions).

In category D (3.60±0.92), the relevance of the information and the presence of illustrations were observed to facilitate navigation and understanding of the application. No apps were scientifically evaluated, and the patient-centric apps did not contain information relevant to fall prevention. Educational applications had a higher Final Average because their assessment took this category into consideration.

Some applications had manual pushbuttons and alerts to external contacts after the fall was detected, however, as the fall can immobilize the patient, this feature can influence the alert, help and assistance. In this context, in some studies[3; 4; 18], the accelerometer sensor on a wearable/smartphone is the main feature used in fall detection as it easily identifies the vibrations associated with the fall.

Table 2. MARS scores

App	Link	A	B	C	D	Average	E
1	https://apps.apple.com/br/app/fallsafety-prosafety-alerts/id870864283	5.00±0.00	4.50±0.50	5.00±0.00	4.50±0.76	4.75±0.25	5.00±0.00
2	https://apps.apple.com/us/app/fallsafety-home-personal-alert/id1097177984	5.00±0.00	4.50±0.50	5.00±0.00	4.33±0.75	4.71±0.30	5.00±0.00
3	https://play.google.com/store/apps/details?id=com.chkincam.fall&hl=pt_BR&gl=US	4.40±0.49	5.00±0.00	5.00±0.00	4.33±1.11	4.68±0.32	5.00±0.00
4	https://play.google.com/store/apps/details?id=com.caringcompany.main&hl=pt&gl=US	4.40±0.80	5.00±0.00	4.67±0.47	4.60±0.80	4.67±0.22	5.00±0.00
5	https://play.google.com/store/apps/details?id=com.tidyware.workersafety.pro&hl=en_US&gl=US	4.80±0.45	4.25±0.83	5.00±0.00	4.00±0.82	4.51±0.40	3.25±0.43
6	https://play.google.com/store/apps/details?id=com.GazGames.SalveVovo&hl=fr_CH	4.00±1.26	4.75±0.43	5.67±0.47	4.17±0.69	4.40±0.32	3.50±1.12
7	https://play.google.com/store/apps/details?id=com.hcpastopfalls&hl=pt_BR&gl=US	3.40±1.96	5.00±0.00	4.33±0.47	4.67±0.75	4.35±0.60	4.50±0.87
8	https://play.google.com/store/apps/details?id=com.healthappy.seizario2&hl=pt_BR&gl=US	4.60±0.49	4.75±0.43	3.67±0.94	4.33±0.75	4.34±0.42	4.50±0.50
9	https://play.google.com/store/apps/details?id=com.Sades.PrevencaoQuedasIdosos	3.20±1.17	5.00±0.00	4.00±0.00	4.00±1.00	4.05±0.64	2.00±1.00
10	https://play.google.com/store/apps/details?id=com.Jump.FallsPrevention	4.20±1.17	3.50±0.50	3.67±0.47	4.50±0.76	3.97±0.40	2.50±0.50
11	https://play.google.com/store/apps/details?id=com.fall.detection	2.80±1.33	5.00±0.00	3.67±0.47	3.83±0.90	3.83±0.78	2.50±1.66
12	https://play.google.com/store/apps/details?id=com.HRscape_grandzangel	4.20±0.75	3.75±0.43	2.00±0.00	4.20±0.75	3.54±0.91	2.00±0.75
13	https://apps.apple.com/us/app/alarm-free/id284728433	1.80±0.75	4.75±0.43	2.67±0.94	2.50±1.26	2.93±1.10	1.25±0.43
14	https://play.google.com/store/apps/details?id=appinventor.ai_salekhan13.freefall	2.00±1.26	5.00±0.00	1.67±0.94	2.75±1.79	2.85±1.30	1.25±0.43
15	https://apps.apple.com/pt/app/care24/id1152041483	2.20±0.98	3.75±0.83	3.00±0.00	1.80±0.98	2.69±0.75	1.00±0.00
16	https://play.google.com/store/apps/details?id=com.anirudh.falldetect	2.00±0.89	4.00±1.22	1.33±0.47	2.25±1.09	2.40±0.98	1.25±0.43
17	https://play.google.com/store/apps/details?id=fall.detectionver2.acc	2.40±0.80	2.50±1.50	2.00±0.82	2.17±1.21	2.27±0.20	1.25±0.43
18	https://play.google.com/store/apps/details?id=com.sjinnovation.gamecoffalls.live	1.40±0.49	1.25±0.43	3.00±0.00	1.80±0.40	1.86±0.69	1.00±0.00
Final average		3.43±0.93	4.24±0.45	3.58±0.36	3.60±0.92	3.71±0.59	2.88±0.47

A – engagement; B – functionality; C – aesthetics; D – information; Final – final average, E – subjective

Also, optimization methods for fall detection algorithms have been researched in recent years, through a previously defined threshold[15; 19], and Machine Learning[8; 10], despite the fact that our sample has considered this last method little.

4. Conclusion

Based on the results presented, it can be concluded that the fall detection and prevention applications available for Android and IOS have good quality after a rigorous assessment carried out via MARS scale. A possible limitation was that many elderly people do not use the smartphone as often as young people, and this can impact the number of applications developed for this purpose.

It is recommended that future research address the development of assessment instruments which are adapted to a context where mHealth solutions are involved. Thus, we would suggest a new method of assessment or the continuation of studies for the development of an app that detect and prevents falls, aimed at the elderly population stemming from the gaps shown in the article.

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