USERS' PERCEPTIONS TOWARDS A NEWLY DEVELOPED MRI MOBILE APPLICATION: THE CASE OF SAUDI ARABIA

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ABSTRACT
Purpose: This paper explored the use of mobile applications to ease paediatric patients' compliance with Magnetic Resonance Imaging (MRI) scans. Specifically, this paper evaluated the effectiveness of a newly developed MRI mobile application specifically designed for young children, aged 4 to 9 years, using the Mobile Application Rating Scale (MARS).
Approach: This paper utilised a quantitative approach where the perceptions of a randomly selected sample of 58 parents of paediatric patients were collected through their responses to the MARS surveys.
Findings: The study found that the application scored highly in most of the evaluated areas (4.3) with high mean values and low variance and standard deviation values indicating that the ratings are consistent and positive across all elements.
Conclusion: The findings indicated that the app was well-received by users and recommended that future research and app. developers should build their applications based on research and informative data. Additionally, the study recommended the development of apps with interactive and animated features that are age-appropriate, informative, and can be customised according to the child's preferences, as well as providing children with options to choose their character's gender and incorporating more than one language option to enhance their experience.

INTRODUCTION & BACKGROUND

Over the past few decades, Magnetic Resonance Imaging (MRI) has become the dominant imaging technique in the medical field due to its capacity to display neuroanatomy, provide clear differentiation between grey and white matter, indicate the level of myelination, and identify specific structural brain lesions (Johnston 2004). MRI not only enables the identification of the cause of partial seizures, but it also surpasses the advantages of computerized tomography (CT) scans when it comes to temporal lobe origin MRI images. MRI also enhances the detection of particular intracranial lesions, notably those affecting the meninges and those caused by vascular issues (Kondziolka et al. 1991; Demiral et al., 2018; Runge et al. 2018; Keesara, Jonas & Schulman 2020). In addition, the use of MRI considerably enhances the level of radiologic specificity, especially when it comes to determining the extent of certain neoplasms and differentiating between benign and aggressive processes (Vougioukas et al. 2006; Urschler et al. 2015).

Although the use of GA is generally regarded as safe and non-harmful for patients in general (Ahn & Bang, 2020), some researchers and practitioners have expressed concerns about the potential long-term effects of GA particularly on paediatric patients (Arthurs & Sury, 2013; Clausen et al., 2018; Low et al., 2008; Odegard et al., 2004; Pasternak et al., 2010). Although not extensively studied, the administration of GA in children may have an impact on their emotional and behavioural development. Moreover and despite of its numerous advantages and its widespread use in the medical field, patient's compliance has been the main problem especially in the paediatric population, taking into account the challenging task of getting little children to comply and remain motionless for an extended period of time, which is critical for ensuring high quality scanning results while undergoing MRI scans (Serafini & Zadra 2008). The researchers further elaborate that alternatively, sedation for paediatric patients or general anaesthesia (GA), have been utilised as aiding methods in different surgical and dental procedures to deal with the paediatric patient's compliance. Therefore, and to minimize the impact of and increase patient safety while reducing costs, medical researchers and practitioners have been exploring various alternatives in the paediatric field. These include mock scanners, remote and MRI-compatible audio-visual systems, and more recently, the development and use of mobile applications designed to simulate the MRI experience (Hallowell et al. 2008).

In recent years, particularly with the advancement of technology and mobile applications, medical professionals have developed and employed numerous applications (McGuirt, 2016). In this context, Nayak et al. (2017) attribute the rapid increase in mobile application utilization across various fields to their unique ability to facilitate remote connectivity with flexibility in design, accessibility, and function. Furthermore, Suchodolska and Senkus (2022) have pointed out that mobile applications have become increasingly popular among healthcare providers and the general public for integrating cancer screening and early detection into standard cancer care. Such mobile applications have also found their way into the MRI scan screening arena with the development of MRI mobile applications for paediatric patients to expose such young groups to the whole process, which would ease and facilitate the compliance needed to ensure high-quality screening results. In this context, Runge et al. (2018) conducted a study that attempted to examine the effectiveness of a newly developed mobile application for paediatric patients and concluded that such method is among the most cost-effective ways to allow children to complete a successful MRI scan without using GA.

Several MRI mobile applications have been developed and are available on App Store (IOS) and Play Store (Android), as shown in Table 1. Specifically, four paediatric MRI-related mobile applications are currently available on the two platforms.

Table 1
MRI Mobile Applications Available on IOS and Android Platforms

Mobile Application	Character Choice	Interactive Features	Platform	Dual Language
HC And https://bit.ly/3N7dKEZ	No character choice is available. The app shows a video of a story of a baby penguin undergoing MRI scanning accompanied by his parents. All users do is watch the events of the story.	One interactive feature is available where users can colour the penguin family when standing next to the MRI machine. No games or other activities are available.	IOS and Android	No dual language is available. The app targets Danish language speakers only.
My MRI at GSTT https://bit.ly/3FFToQE	No character choice is available. The application represents a track video of a little boy who undergoes MRI scanning, and it showed the boy's journey from the moment he entered the hospital until the moment he left the MRI scan room. No girl's option is available as a character.	No interactive feature is available in which users have only one option, which is watching the little boy getting into the hospital and experiencing the MRI scanning.	IOS and Android	No dual language is available. The app targets English language speakers only.
MRI Scan Experience https://bit.ly/3M7Y0lj	No character choice is available in terms of gender, but users can choose between an adult option or a child option.	One interactive feature was included in the app where users can listen to the MRI noise from the MRI machine and the same time, they can compare the noise to the sound from other objects and animals such as a vacuum cleaner, trumpet, a dog, or an elephant.	Android users only. Not available on IOS	No dual language is available. The app targets English language speakers only.
Hetty's Hospital https://apple.co/3yv7nY2	No character choice is available. The application is not specifically designed for MRI, but a video of a general visit experienced by Hetty and her friend, Charlie to the hospital. One MRI scanning scene was included for post leg fracture.	Yes. The application included features of interactive games and conversation platform to allow interaction among kids and hospital personnel.	IOS users only. Not available on Android	No dual language is available. The app targets English language speakers only.

Almutairi et al. (2023) conducted a study that attempted to provide an evaluation and a breakdown of these four mobile applications shown in the table above. The researchers highlighted a few areas to address by future researchers and application developers in the field of MRI mobile applications. One of the areas highlighted in their study is that none of the applications provided the option for children to choose the gender of the character they wished to accompany them during the scan, which could negatively affect their user experience. Additionally, only a limited number of interactive features were available in most of the applications.

None of the four applications reviewed offered more than one language option. The researchers further elaborated that the main issue with the current mobile applications for MRI is that they are designed for adult users, with lengthy scientific texts and limited interactive features. Although some sections within the apps are designated for kids, they are not appealing to them. The study recommended the development of apps with interactive and animated features that are age-appropriate, informative, and can be customized according to the child's preferences. Providing children with the option to choose their character's gender and incorporating

more than one language option would also improve their user experience.

The study concluded with a recommendation to future research and app developers to build their applications based on research and informative data. This current study responds to their recommendations by conducting a quantitative research design through the use of surveys administered to parents of paediatric patients to evaluate a newly developed MRI mobile application specifically designed for young children, aged 4 to 9 years old.

METHODOLOGY
This study employed a quantitative research methodology using a survey as the primary instrument through which the data is collected. The population of the study includes all the parents of the paediatric patients (ages 4-9 years old) undergoing MRI screening in King Suad Hospital in Saudi Arabia for a duration of six months (October 2022 – March 2023) from the start of the data collection procedures utilising a simple random sampling technique. The data collection tool utilised in this study was the Mobile Application Rating Scale (MARS) which comprises five main categories, namely Engagement, Functionality, Aesthetics, Information Quality, and finally Subjective Quality. The data were analysed using Statistical Package for Social Sciences (SPSS) and Microsoft Excel where the frequencies, means, and standard deviations of the individual ratings of each of the dimension of the MARS were calculated and reported. Those participants who were unwilling to provide the consent from were excluded from the study.

The Mobile Application Rating Scale (MARS) is a well-established measurement tool and is described as the only available tool that provides a comprehensive, multidimensional evaluation of application quality, which has been used to compare and evaluate mobile applications in general and medical mobile apps in particular, as indicated by Bardus et al. (2020). The MARS is comprised of 5 main categories consists of engagement, functionality, aesthetics, information quality, and subjective quality that are measured on a 5-point Likert scale from strongly agree to strongly disagree. Each category is measured through a set of elements. Specifically, the engagement category consists of five elements, namely entertainment, interest, customisation, interactivity, and target group. The functionality category consists of four elements, namely performance, ease of use,

navigation, and gestural design. The third category, aesthetics, consists of three elements, namely layout, graphics, and visual appeal. The fourth category, information, consists of 4 elements, namely goals, quality of information, visual information, and credibility. The final category, subjective quality, consists of four elements, namely recommendation, payment, times of use, and overall rating. The MARS measure has been tested in many studies in the field of mobile applications including those in the medical field and has been proven to be both valid and reliable (Messner, et al., 2020). The MARS measure has been tested in many studies in the field of mobile applications including those in the medical field and has been proven to be both valid and reliable.

Prior to conducting the MARS surveys, all participants were requested to sign a consent form, and at the same time, they were ensured that participation was voluntary and that they could withdraw from participation at any given time without providing an explanation. The participants were also reminded that their data would be kept anonymous and would not be shared with anyone and that the data would only be used for academic, research, and development purposes. In addition to that, contact details of the researchers were provided to all participants should they need any further details or explanation.

Total of 58 parents of paediatric patients participated in responding to the MARS questionnaires through an online survey with an integrated link to download and try out the newly developed mobile application prototype which was developed on MIT App Inventor platform. This newly developed MRI mobile application was specifically designed to respond to the recommendations and at the same time addressed all of the points and issues reported in Almutiari et al.'s (2023) study in terms of providing a gender option for users, providing a dual language (Arabic and English), incorporating localised characters wearing the local Saudi clothes, providing interactive features and games for children, and providing simple and user friendly interface that is suitable for such young group of users.

RESULTS & DISCUSSION
Fifty-eight responses have been received from parents of paediatric patients, and their demographic statistics were as detailed in the figure below in terms of the age of their children.
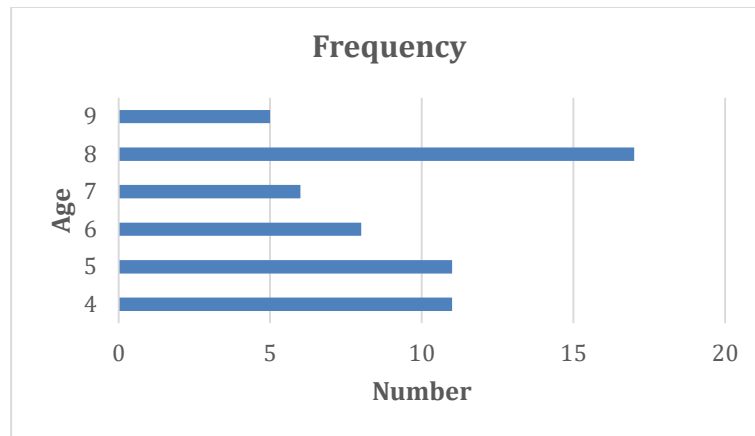
Frequency

Figure 1
Demographic Statistics – Children's Age

As shown in the figure above, the parents of the children scheduled for MRI scans in King Saud Hospital indicated that their children are of different ages ranging from four to nine years old, which was the target group for this study. Specifically, out of the 58 respondents, 11 respondents indicated that their children are four years of age, 11 other respondents indicated that their children are five years of age, eight respondents reported that their children are six years old, six respondents reported that their children are seven years of age, 17 respondents indicated that their children are eight years old, while five parents indicated that their children are nine years old.

Another demographic factor investigated in this study is the gender of the paediatric patients. Table 4.2 below shows the gender differences between the paediatric patients as reported by their parents.

Tabel 1
Demographic Statistics - Gender

Gender	Frequency	Percentage
Male	20	34.5%
Female	38	65.5%
Total	58	100%

As shown in the table above, the majority of the paediatric patients involved in this study are females, with 65.5% of the total sample, while male paediatric patients constitute 34.5% of the sample. The table below (Table 2) shows the statistical results of the five categories of the MARS questionnaire.

Table 2

Mobile Application Rating Scale (MARS) – Statistical Analysis

Dimension & Elements	Mean	Variance	Std Deviation	Sum
Engagement (ENG)	**4.43**	**0.32**	**0.57**	**1284**
ENG1. Entertainment: Is the app fun/entertaining to use? Does it use any strategies to increase engagement through entertainment (e.g. through gamification)?	4.50	0.39	0.63	261
ENG2. Interest: Is the app interesting to use? Does it use any strategies to increase engagement by presenting its content in an interesting way?	4.3	0.30	0.55	252
ENG3. Customisation: Does it provide/retain all necessary settings/preferences for apps features (e.g. sound, content, notifications, etc.)?	4.47	0.29	0.54	259

ENG4. Interactivity: Does it allow user input, provide feedback, contain prompts (reminders, sharing options, notifications, etc.)? Note: these functions need to be customisable and not overwhelming in order to be perfect.	4.34	0.34	0.58	252
ENG5. Target Group: Is the app content (visual information, language, design) appropriate for your target audience?	4.48	0.29	0.54	260
Functionality (FUNC)	**4.63**	**0.25**	**0.50**	**1075**
FUNC1. Performance: How accurately/fast do the app features (functions) and components(buttons/menus) work?	4.67	0.22	0.47	271
FUNC2. Ease of Use: How easy is it to learn how to use the app; how clear are the menu labels/icons and instructions?	4.71	0.25	0.50	273
FUNC3. Navigation: Is moving between screens logical/accurate/appropriate/ uninterrupted; are all necessary screen links present?	4.60	0.24	0.49	267
FUNC4. Gestural Design: Are interactions (taps/swipes/pinches/scrolls) consistent and intuitive across all components/screens?	4.55	0.29	0.54	264
Aesthetics (AST)	**4.57**	**0.27**	**0.52**	**795**
AST1. Layout: Is arrangement and size of buttons/icons/menus/content on the screen appropriate or zoomable if needed?	4.57	0.28	0.53	265
AST2. Graphics: How high is the quality/resolution of graphics used for buttons/icons/menus/content?	4.50	0.29	0.54	261
AST3. Visual Appeal: How good does the app look?	4.64	0.24	0.49	269
Information (INF)	**4.56**	**0.35**	**0.59**	**1057**
INF1. Goals: Does app have specific, measurable and achievable goals?	4.66	0.30	0.55	270
INF3. Quality of Information: Is app content correct, well written, and relevant to the goal/topic of the app?	4.66	0.30	0.55	270
INF3. Visual Information: Is visual explanation of concepts – through charts/graphs/images/videos, etc. – clear, logical, correct?	4.74	0.20	0.44	275
INF4. Credibility: Does the app come from a legitimate source (specified in app store description or within the app itself)?	4.18	0.43	0.65	242
Subjective Quality (SQ)	**3.74**	**0.24**	**0.49**	**773**
SQ1. Would you recommend this app to people who might benefit from it?	4.84	0.13	0.37	281
SQ2. How many times do you think you would use this app in the next 12 months if it was relevant to you?	2.17	0.25	0.50	126
SQ3. Would you pay for this app?	1.81	0.30	0.54	105
SQ4. What is your overall star rating of the app?	4.5	0.29	0.54	261

The data in Table 2 represents the results of a user experience (UX) study on the MRI mobile application. The categories are broken down into various elements, each with their own mean, variance, standard deviation, and sum. The mean represents the average rating given by the participants for that element, with higher values indicating higher satisfaction. The variance and standard deviation

provide information about the spread of the data and how much the ratings for that element vary. The sum represents the total number of points awarded for that element. Specifically, the table presents the results of a study that evaluated an app using five dimensions: engagement, functionality, aesthetics, information, and subjective quality. Each category is composed of several sub-categories (elements), with each having its own mean, variance, standard deviation, and sum.

Engagement category measures how much users are engaged with the app, and how much they are interested in using it. It includes sub-dimensions such as entertainment, interest, customisation, interactivity, and target group. The mean value for this category is 4.43, indicating that users generally have a positive engagement with the app. As for the functionality dimension, this dimension measures how well the app performs and how easy it is for users to use. It includes sub-dimensions such as performance, ease of use, navigation, and gestural design. The mean value for this dimension is 4.63, indicating that the app performs well and is easy to use. As for the Aesthetics dimension, this dimension measures how visually appealing the app is. It includes sub-dimensions such as Layout, Graphics, and Visual Appeal. The mean value for this dimension is 4.57, indicating that the app has a visually appealing layout and high-quality graphics. As for the Information dimension, this dimension measures the quality and relevance of the information provided by the app. It includes sub-dimensions such as Goals, Quality of Information, Visual Information, and Credibility. The mean value for this dimension is 4.56, indicating that the app provides high-quality and relevant information. Finally, the Subjective Quality dimension measures users' overall perception and satisfaction and indicated a positive overall outlook and satisfaction apart from the willingness to pay for the mobile application.

Thus, overall, the data suggest that the app is well-received by users, with high mean values and low variance and standard deviation values indicating that the ratings are consistent and positive across all elements. Findings from this study indicate that the ratings are consistent and positive across all elements. These findings are in line with previous studies on Mobile App Rating Scale (MARS), which have shown that high mean values and low variance and standard deviation values suggest that the app is well-received by users (Stoyanov et al., 2015). While the means regarding the five categories were reported to lean on the positive side and were also close to each other in terms of value, apart from the last category, the means regarding the three categories of functionality, aesthetics, and information were all above 4.5 indicating relatively more positive results than the other two categories of engagement and subjective quality. This finding is consistent with previous research on MARS, which has identified functionality, aesthetics, and information as important factors in user satisfaction (Stoyanov et al., 2015; Hou et al., 2019) and suggests d the application is well-designed and useful. Furthermore, users may prioritise the functional aspects of the app, such as ease of use and navigation, because these are directly related to the app's ability to meet their needs and achieve their goals. Previous research has shown that perceived usefulness and ease of use are important factors in user satisfaction with mobile apps (Davis, 1989; Venkatesh et al., 2003). In addition to that, aesthetics may have played a role in users' positive ratings because visual appeal and design can influence user engagement and enjoyment of the app, and this has been addressed in the relevant literature where previous studies have shown that aesthetics can influence user perceptions of an app's quality and usability (Tractinsky et al., 2000; Hassenzahl et al., 2003). More importantly, the information category may have been rated higher because users may place importance on the accuracy and relevance of the information presented in the app especially in the context of health-related apps that need to provide reliable and relevant information to users to meet their needs and improve health outcomes and at the same time avoid any health risks (Stoyanov et al., 2015).

On the other hand, engagement and subjective quality may have been rated lower than the other categories because they are more subjective and may depend on individual preferences and perceptions. For example, one user may find an app engaging and enjoyable, while another may not. One possible explanation for the lower rating in the subjective quality category, which scored significantly lower than the other four categories, is that it contained a question about users' willingness to pay for the mobile application, with the majority reporting that they were unwilling to pay. This may have influenced their overall perception of the app's quality and value. The availability of free alternative apps in the market, regardless of their quality, may have made users less willing to pay for the app, even if they rated its functionality, aesthetics, and information highly. Previous research has shown that perceived value and price are important factors in users' decisions to adopt and continue using mobile apps (Venkatesh et al., 2003; Lu et al., 2010; Molina-Castillo, Lopez-Nicolas & de Reuver, 2020).

This study attempted to respond to the calls and recommendations of other papers in the field of Magnetic Resonance Imaging (MRI) and associated mobile applications. The study by Almutairi et al. (2023) evaluated four MRI mobile applications currently available on IOS and Android stores and highlighted the need for future app developers to create age-appropriate, interactive, informative, and customisable applications based on research

data. This paper further responds to their recommendations by evaluating a newly developed MRI mobile application specifically designed for young children.

CONCLUSION AND RECOMMENDATIONS

The findings of the study revealed that the app was well-received by users, with high mean values and low variance and standard deviation values indicating that the ratings are consistent and positive across all elements. It is hoped that such evaluations will result in the future development of more high-quality and user-friendly MRI mobile applications that can enhance patient safety, reduce costs, and improve the overall MRI experience for paediatric patients which would positively impact the clinical setting related to paediatric MRI use. Future research is encouraged to develop and examine new MRI mobile applications for paediatric patients that are contextualised and localised to the local cultural and linguistic settings.

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