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Patient Experience and Virtual Reality: The Use of an MRI Exam Simulator

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ABSTRACT

Magnetic resonance (MR) imaging is a safe diagnostic method of high accuracy detection and characterization of various pathological conditions. However, due to the very closed aspect of the apparatus, the high sound amplitude emitted and the need to remain motionless for a significant time, some patients experience discomfort and high levels of anxiety, compromising time and image quality management that can impair the clinical outcome of the patient or even give up the performance of this procedure. Therefore, this study aimed to validate, with patients, the use of Virtual Reality (VR) as a humanized practice of exposure to magnetic resonance imaging, to reduce the discomfort often present in the procedure. For this purpose, we used a cross-sectional method of quantitative-qualitative approach, incorporating purposeful sampling and semi-structured interviews of evaluative nature with 303 patients from two health institutions located in the state of Alagoas, Brazil, in which patients immersed in VR before the examination. As a result, exposure to VR led 98.9% of patients to feel more prepared and confident to perform the examination. There was no significant correlation between age, previous contact with technology and gender with the effectiveness of the intervention. However, there was a significant correlation between the form of approach, the quality of information and the level of feeling of relaxation of the patient. Thus, these results highlight the positive impact of VR on the patient’s experience in performing the MRI examination and the variety of audiences that can enjoy the benefits that this technology provides.

Keywords: Patient experience, patient-centered care, technology, health mindfulness

1. Introduction

1.1. Magnetic resonance imaging and discomfort

Magnetic resonance imaging is currently the most important diagnostic tool in clinical practice. This is based on using a method that provides images with high spatial and contrast resolution, which in the health field can be used both in the detection and characterization of numerous pathological conditions. MRI is a painless and non-invasive procedure for those who use it. In essence, the examination apparatus manipulates powerful magnetic fields and radio waves to generate images of organs and...
physiological processes. It is considered a safe method that can be repeated several times, depending on the need and the way it is administered.

As a result, its use has been growing over the years and is currently configured as one of the most used diagnostic imaging tools, data from 2022 show that there are about 2847 magnetic resonance equipment in Brazil and 2424 equipment in use, 923 of which are available in the SUS, with a density of 1.19 devices per 100 thousand inhabitants. Between January 2022 and January 2024, 4.3 million MRI scans were performed between private and public companies in Brazil. However, even being a biologically safe procedure, powerful in its purpose, and relatively common nowadays, some patients experience discomforts and high levels of anxiety that compromise the diagnostic quality of the process. Conscious or unconscious sedation may be necessary with the help of the physician Anestesista.

The discomfort and anxiety around the MRI exam are mainly linked to the closed aspect of the device itself, the high sound amplitude emitted during the execution of the machine sequences and the need to remain still for a significant time. In addition, they also relate to other factors, such as the lack of knowledge of what to expect at the time of the examination and the own apprehension about what the result may show.

The levels of discomfort and anxiety of patients can be so intense as to cause changes in the autonomic nervous system disproportionate to the present situation and that go beyond the voluntary control of individuals. These changes cause panic feelings manifested by a series of symptoms, such as cardiorespiratory changes, palpitations, sweating, feeling of asphyxia, chest pain, dizziness and even fainting.

From the perspective of behavioral psychology, anxiety is understood as a set of bodily states elicited by aversive stimuli that disturbs the operating performance of an individual, that is, it is the anticipation of a future danger, when this anticipation is accompanied by dysphoria or tension symptoms. Anxiety and fear are reactions that activate the fight or flight system of organisms and can be considered products of early environmental experiences, influenced by biological susceptibility factors that impact the brain structurally or functionally.

Physiologically, fear and anxiety are mainly linked to the subcortical region of the cerebral amygdala that when activated together with the insula and the anterior cingulate cortex trigger the characteristic physiological responses to these conditions. Exposure-based therapies have been shown to be effective in the treatment of these reactions, since there is evidence that they are able to act in these same brain areas (amygdala, insula and the anterior cingulate cortex) known as “fear network.”

There is also evidence that demonstrates how the use of Virtual Reality can be a valuable resource to help these therapeutic methods. This can be explained by this technology allowing the sense of presence and the feeling of being in a certain environment when, in fact, it is in other, which becomes effective since the brain does not distinguish what is real from what is projected.

1.2. Virtual reality and patient experience

This context of fear and anxiety triggers a series of negative repercussions to patients, among them, we highlight: (1) deprives itself of the results of Magnetic Resonance Imaging, when it is not able to perform it, to contribute to its diagnosis; (2) have less accurate diagnosis due to low quality images due to anxiety; (3) resort to sedation adding risks to the procedure; and (4) loss of time and financial resources of logistical expenses for the execution of the procedure when reschedule.

In view of this scenario, the use of virtual reality is presented as an innovative initiative to improve the patient experience, excellence in the hospital journey and in clinics and minimize discomforts and anxieties involved in the process of performing the examination. Virtual reality can be understood as an advanced interface for computational applications, capable of providing user immersion in three-dimensional environments that are capable of interaction and exploration in real time.

In the health field, this technology has already proven to be beneficial both in the education of professionals and in the health care sphere itself. In the Brazilian scenario, virtual reality permeates the area of medicine, physiotherapy and nursing and presents successful initiatives in several regions, contributing to higher quality services and bringing new possibilities and opportunities.

In addition to having the potential to improve the quality of services provided, the use of virtual reality can above all contribute to the improvement of the patient experience. It is understood that the concept of the term patient experience is not something
simple and can be confused with other concepts, such as satisfaction, loyalty and engagement. However, it is noteworthy that the patient’s experience is more than simple customer satisfaction.

From this perspective, the Beryl Institute defines patient experience as “the sum of all interactions, shaped by an Organization’s Culture, that Influence Patient Perceptions Across the continuum of care.” Thus, the patient experience is aligned with (1) individualized care, (2) the adaptation of services to meet the needs of patients and involve them as partners in their care, (3) the positive fulfillment of patients’ expectations and (4) the practice of patient and family centered care.

This paradigm has increasingly become a concern of health institutions, since the patient’s experience reflects the quality of services from the patient’s perspective, that is, the subject who makes use of products and services. The experiences experienced by patients help them choose both professionals and health institutions that will perform consultations and care.

In this sense, there is a growing trend towards improving health services based on what patients truly value, such as access to information, individualized care and, above all, being treated as people, not as numbers in a list. Thus, given the need for a systematic orientation in the psychological preparation of the client for the realization of diagnostic processes by image, this study aimed to validate with patients the use of Virtual Reality as a humanized practice of exposure to magnetic resonance imaging, to reduce the discomfort often present in the procedure.

2. Method

2.1. Study design

This study used a cross-sectional clinical design of quantitative-qualitative approach of evaluative nature, incorporating purposeful sampling and semi-structured interviews of evaluative nature. The approval of the research was granted by the Research Ethics Committee with protocol n° 4.065.296.

2.2. Context

The scenarios of this study were two health institutions located in the state of Alagoas, Brazil. Being them, the university hospital Professor Alberto Antunes located in the capital (Maceió) and a clinic specialized in diagnostic imaging located in a municipality of the interior (Arapiraca). Both sites were chosen because they are located in strategic geographic points, since they receive patients from several other municipalities in the state, which enabled a more heterogeneous sample of participants.

2.3. Sampling and recruitment

The sample was used to recruit participants in this study. This approach allowed the recruitment of marked patients to perform the MRI procedure in the two spaces mentioned. The invitations to participate were made within the health institutions themselves.

The sample consisted of adult individuals, of both sexes, aged over 18 (eighteen) years, conscious and lucid, with confirmed diagnosis or not of specific phobia anxiety disorder. Children under 18 (eighteen) years old, people with visual impairment, people with eye diseases or who had labyrinthitis, and people with severe mental disorders were excluded from the sample.

2.3.1. Sample size

The study was conducted with a sample of 303 participants, determined based on the resources and time available for the research. Within this group, 123 participants were approached in the hospital environment, while the other 180 were recruited in the clinical environment. This division of the sample allowed a comprehensive evaluation of the effects of the Virtual Reality simulator in different application contexts, contributing to a more complete analysis of the data obtained.

2.4. Data collection

Data collection took place in loco of health institutions. Initially a mapping of the patient’s journey in each institution was carried out, soon after was delimited the best time for the use of Virtual Reality to adapt the logistics of space and not hinder the flow of tests. Based on these initial preparations, we chose in both spaces to use Virtual Reality when patients were already fully prepared to enter the examination room and waited their turn in the waiting room.

After that, the patients were approached in the waiting room by a member of the research team and they were offered the opportunity to experience an immersion in Virtual Reality with the use of Meta Quest 2 Virtual Reality glasses with software that simulates the Magnetic Resonance Imaging examination process in 3D, intended to familiarize and calm
the patient, with an average duration of minutes distributed in three distinct moments (scenario 1, MRI simulator and scenario 2) as shown in Fig. 1.

After acceptance of participation, the glasses were adjusted and the participants immersed themselves in a virtual environment composed of all stages of a Magnetic Resonance examination, from the ambience of the room, going through entering the machine, listening to the sounds of the sequences, up to general guidance on the procedure regarding both time and body position.

After the experience, structured interviews were conducted with all participants, composed of open questions, and closed questions measured on a five-point Likert scale, such as “What is the feeling you are feeling at this moment? And what is your level of relaxation after this experience?”.

### 2.5. Data analysis

After data collection, a process of tabulation of information was initiated in which all data from the two health institutions were grouped. From this, a qualitative analysis was performed, using descriptive statistics regarding the frequency of responses obtained through interviews with participants.

### Table 1. General characteristics of the sample.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital</td>
<td>123</td>
<td>40.6%</td>
</tr>
<tr>
<td>Clinic</td>
<td>180</td>
<td>59.4%</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>199</td>
<td>65.7%</td>
</tr>
<tr>
<td>Women’s</td>
<td>104</td>
<td>34.3%</td>
</tr>
<tr>
<td>Age range</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18–29</td>
<td>43</td>
<td>14.2%</td>
</tr>
<tr>
<td>30–39</td>
<td>48</td>
<td>15.9%</td>
</tr>
<tr>
<td>40–49</td>
<td>70</td>
<td>23.1%</td>
</tr>
<tr>
<td>50–59</td>
<td>71</td>
<td>23.4%</td>
</tr>
<tr>
<td>60 or more</td>
<td>71</td>
<td>23.4%</td>
</tr>
<tr>
<td>Examination type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With contrast</td>
<td>142</td>
<td>46.9%</td>
</tr>
<tr>
<td>No contrast</td>
<td>161</td>
<td>53.1%</td>
</tr>
<tr>
<td>Contact with technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did not know</td>
<td>169</td>
<td>58.1%</td>
</tr>
<tr>
<td>Saw on Television</td>
<td>86</td>
<td>29.6%</td>
</tr>
<tr>
<td>Had contact but never used</td>
<td>28</td>
<td>9.6%</td>
</tr>
<tr>
<td>Already used</td>
<td>8</td>
<td>2.7%</td>
</tr>
</tbody>
</table>

Subsequently, statistical tests of non-parametric character were used, being those resources that do not require the analyzed data to follow a normal distribution, which in turn makes the analysis more flexible, contemplating both ordinal data (classifications), as nominal data (categories), in addition to being less influenced by outliers since they do not depend on measures such as means and variances. It is worth noting that nonparametric tests provide a variety of insights such as understanding the distribution of data, differences between groups, associations and correlations. In view of this, this study used Spearman’s correlation test in ordinal and quantitative qualitatives,

### 3. Results

In all, 303 patients went through the experience of experiencing the Magnetic Resonance simulator through the use of Virtual Reality during their trajectory of care in health institutions. Table 1 shows a summary of the general characteristics of these patients and the variability of the data collected in the two study sites.

It is noted that 40.6% of the participants in this study were hospital patients, while the other 59.4% were patients in the clinic. Analyzing the general data of these two institutions, there is a slight predominance of male participants (65.7%) in relation to the female gender (34.3%).

In addition, it is possible to observe that the distribution of participants by age group is relatively uniform,
with a significant presence in all bands. Regarding the type of examination, with contrast and without contrast, the division between the participants is balanced, being, respectively, 46.9% and 53.1%.

Regarding previous contact with Virtual Reality technology, the majority of participants, 58.1%, said they had never had contact with this technology before. While a smaller share, 29.6% said they have seen the technology only on television. In addition, 9.6% of the participants reported having had some previous contact with Virtual Reality, even if they had never actually used it, and only 2.7% of all patients had used it before this study.

When looking closely at the data, there is a heterogeneous distribution of the ages of the participants in relation to each category of contact with Virtual Reality technology, suggesting an association between age and familiarity with this technology.

Fig. 2 shows this phenomenon and indicates that participants who had no prior knowledge of Virtual Reality tended to be older, with a median age of 52 years. In contrast, participants who saw Virtual Reality on television or had some previous contact with this technology, but never used it, had lower medians of age, 41 and 36 years, respectively. Following this trend, participants who had already used the technology at some point before this study had the lowest median age recorded, being 28.5 years.

In view of this, it is inferred that access to this technology is still restricted to a small portion of the population, since, as previously highlighted, more than 50% of the sample studied had no previous contact with this technology, while only 2.7% came to use it. In addition, the age factor is a variable that influences access to Virtual Reality, since the data show that younger participants were more familiar with this technology, while older participants appeared to be less likely to have previous contact with this feature.

4. Discussion

The classification of the quality of the information provided on the Magnetic Resonance examination through the intervention with the Magnetic Resonance simulator on a scale of 0 to 10 was assigned by the participants of this study with grades ranging from 7 to 10. The highest percentage recorded was score 10 (77.6% of the responses collected), followed by score 9 (22.4%) and scores 8 and 7 (6.9% and 1.7%, respectively). This information suggests how this model of intervention can improve communication between employees of the service with their patient.

In addition, in a 5-point Likert scale, 2.6% of the participants attributed a grade of 3 to the level of relaxation caused by the intervention with the Magnetic Resonance simulator, while 14.2% attributed a grade of 4 and the other 83.2% of the patients attributed a maximum grade, that is, 5 points, showing the effectiveness of this technology in order to improve the experience of patients, reducing the discomfort often present in the MRI procedure, similar to results already found in the literature.
Table 2. Correlation matrix.

<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>Quality of information</th>
<th>Level of relaxation</th>
<th>Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age Rho of Spearman</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Gl</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>p-value</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Quality of information Rho of Spearman</td>
<td>0.073</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Gl</td>
<td>301</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>p-value</td>
<td>0.204</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Level of relaxation Rho of Spearman</td>
<td>0.096</td>
<td>0.691***</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Gl</td>
<td>301</td>
<td>301</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>p-value</td>
<td>0.096</td>
<td>&lt;0.001</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Indication Rho of Spearman</td>
<td>0.027</td>
<td>0.292***</td>
<td>0.331***</td>
<td>—</td>
</tr>
<tr>
<td>Gl</td>
<td>301</td>
<td>301</td>
<td>301</td>
<td>—</td>
</tr>
<tr>
<td>p-value</td>
<td>0.643</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>—</td>
</tr>
</tbody>
</table>

Note: *** p < 0.001.

This statement is corroborated by finding that 98.3% of the participants stated that they would use the Magnetic Resonance Imaging simulator again if they need to repeat the examination in future occasions. In addition, 94.4% attributed the maximum score for the probability of indicating the health institution to other patients who need to perform the same diagnostic procedure due to experience.

It is worth noting that 98.9% of all participants verbalized having a feeling of well-being, host or even safety during the use of the resource and added to this felt more prepared and confident to perform the MRI examination after the experience with the simulator technology. This demonstrates how this humanized care can yield favorable fruits for both patients and institutions.

Similar results were found in a randomized pilot study with women and Virtual Reality, in which he demonstrated that the contact with nature in a virtual way due to the limitations of the metastatic disease, offer lasting benefits for the physical and psychological well-being of women with metastatic breast cancer, showing reductions in fatigue, pain, anxiety, and quality of life of patients in the long term even after the end of Virtual Reality.

It is estimated that worldwide about 2 million MRI procedures cannot be performed annually due to premature interruption or refusal of patients to be examined due to anxiety. According to a systematic review and meta-analysis, claustrophobia is a real problem for the effective execution of the MRI examination, since approximately 1 in 100 people examined has a claustrophobic reaction that requires premature termination of the examination.

This scenario causes a series of practical complications both for health institutions (in the organizational and financial sphere) and for patients at the individual level. Thus, formulating interventions that value the patient’s experience can minimize the problem, optimizing time and resources for both parties, highlighting the use of Virtual Reality as an innovative initiative in the area.

The samples studied in this study, as characterized in Table 1, was heterogeneous. From this perspective, the influence of certain variables on the experience of this intervention was verified. According to previous research, it is common for older adults to have less access to new technologies. Based on this information, there was a hypothesis that age could influence the acceptance and consequently the effectiveness of this technology in different age groups, since younger participants could be more receptive to Virtual Reality due to their familiarity with it, whereas elderly patients could have impaired acceptance and efficacy.

However, when performing the statistical test of Spearman correlation, detailed in Table 2, it was found that there was no statistically significant correlation between age and quality of information provided through Virtual Reality, or even between the age and level of relaxation provided by this technology, nor correlation between age and the probability of indicating health institutions to others.

These data reveal that the intervention using of the Magnetic Resonance simulator to improve the patient’s experience in the Magnetic Resonance procedure is not influenced by the age group that the subject is.

In addition, the non-parametric Kruskal-Wallis test was performed to compare the grouping variable “contact with technology”, having as dependent variables: “level of relaxation”, “quality of information”
and “indication”. The results of the test, as shown in Table 3, indicate that no statistically significant differences were found between the contact groups with the technology. That is, regardless of whether patients have no previous knowledge, have seen only on television, have had previous contact without effective use or even have already used Virtual Reality, all of them can enjoy its benefits and have the opportunity for a more humanized diagnostic experience without any apparent disadvantage.

Following this path, we also sought to compare the samples of the variables “level of relaxation”, “quality of information” and “indication” between the groups of female and male gender. For this, the Mann-Whitney test was used to measure how much the two samples differed from each other.\(^2\) The results, as expressed in Table 4, show that for the relaxation level, the Mann-Whitney U statistic is 10294 and the p-value is 0.909; for the quality of information, the Mann-Whitney U statistic is 10107 and the p-value is 0.648; and for the indication, the Mann-Whitney U statistic is 10020 and the p-value is 0.257.

The findings indicate that there are no statistically significant differences between the female and male groups in relation to the level of relaxation, quality of information and indication. Showing that, in this study, gender did not influence positively or negatively the results of the proposed intervention, that is, men and women were equally benefited.

In view of all this, it is worth highlighting some other key points that stand out in the analysis of the data. When looking closely at Table 2, already mentioned above, the p-value of the matrix of \(<0.001\), suggests a statistically significant correlation between the quality of information provided to participants with Virtual Reality and the level of relaxation reported by them.

Spearman’s Rho is a measure of the strength and direction of the relationship between two variables. In the context of this study, the value of 0.691 reveals a strong positive correlation between the quality of past information and the level of relaxation of the participants. In other words, this demonstrates that the higher the quality of the information provided about the examination procedure, the higher the level of relaxation reported by the participants (Table 2).

Complementing these results, Table 2 still expresses significant relationships between the quality of past information, the level of relaxation of the participants and the probability that patients will indicate the health institution to other people who need to perform the same diagnostic procedure. This suggests how much to value and invest in the patient experience can be beneficial for both the patient himself and the health institution that provides the care. The quality of information and the use of technological resources is pointed out by Reychav and collaborations\(^3\) as relevant to improve patient education in a clinical environment, resulting in a dynamic in higher levels of patient training, influencing your empowerment and helping you better understand your situation, enabling an increase in the sense of

### Table 3. Kruskal-Wallis test between technology contact groups.

<table>
<thead>
<tr>
<th>Variable</th>
<th>(\chi^2)</th>
<th>GL</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relaxation level</td>
<td>3.50</td>
<td>3</td>
<td>0.321</td>
</tr>
<tr>
<td>Quality of information</td>
<td>3.54</td>
<td>3</td>
<td>0.315</td>
</tr>
<tr>
<td>Indication</td>
<td>6.33</td>
<td>3</td>
<td>0.097</td>
</tr>
</tbody>
</table>

### Table 4. Mann-Whitney test between genders.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relaxation level</td>
<td>U Mann-Whitney 10294</td>
<td>0.909</td>
</tr>
<tr>
<td>Information quality</td>
<td>U Mann-Whitney 10107</td>
<td>0.648</td>
</tr>
<tr>
<td>Indication</td>
<td>U Mann-Whitney 10020</td>
<td>0.257</td>
</tr>
</tbody>
</table>

Note: Female \(\mu\) \(\neq\) Male \(\mu\).

![Fig. 3. Level of relaxation in relation to gender.](image-url)
5. Conclusion

It is concluded, through the analysis of the data, that the use of Virtual Reality exerted a substantial impact on the experience of patients during the patient’s journey in health institutions in the procedure of Magnetic Resonance Imaging. The simulator used during the intervention proved to be effective in providing a more informed and controlled experience.

Variables such as age, previous contact with technology and gender showed no significant correlation with the results of the intervention, showing that a variety of people can enjoy the benefits that this experience provides.

In this sense, Virtual Reality allowed participants to know all the possibilities found in a real situation of MRI examination. At the same time, it made it possible to adjust the degree of exposure convenient to each case, even allowing to interrupt the experiment as a function of the reaction that one had at the time. Thus, patients had access in advance to all the information necessary for a good being both properly and individually instructed and experiencing through their senses the examination procedure in a safe environment with controlled variables.

This scenario corroborates the effectiveness of interventions such as Virtual Reality in promoting a truly patient-centered approach, as it promotes a more positive and humanized experience during complex medical procedures, such as MRI.

Conflict of interest

The authors declare no conflict of interest.

References


