



# Can virtual reality reduce pain and anxiety in pediatric emergency care and promote positive response of parents of children? A quasi-experimental study

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## ABSTRACT

**Aim:** To evaluate the effectiveness of virtual reality to reduce pain and anxiety in pediatric patients during venipuncture procedure in emergency care and the behavioral response of their parents/companions.

**Background:** Virtual reality is being used as a source of distraction in children undergoing invasive procedures.

**Methods:** Quasi-experimental study with 458 children (from 2 to 15 years) who attended a pediatric emergency service from September 2019 to April 2021. An intervention based on virtual reality as a distraction method during venipuncture procedure was applied. The level of pain and anxiety of children and attitude of parents/companions were assessed. Ordinal and binary logistic regressions were applied.

**Results:** A protective effect of using virtual reality was observed in the intervention group both for the absence of pain (−4.12; 95 % CI: −4.85 to −3.40) and anxiety (−1.71; 95 % CI: −2.24 to −1.17) in children aged between 2 and 15 years. A significant reduction in the blocking response of the accompanying parents (−2.37; 95 % CI: −3.017 to −1.723) was also observed.

**Conclusions:** VR is effective in reducing pain and anxiety in children during venipuncture in emergency care. A positive attitude of the parents during the invasive procedure to their children was found.

## 1. Introduction

During emergency room stays, invasive procedures are commonly performed for diagnostic and/or therapeutic purposes, which generates an increase in pain and anxiety levels in children [1,2]. Intravenous catheterization, venipuncture or wound sutures are among the most widely used procedures in emergency units globally [3]; at the same time, they are among the most feared by pediatric patients [4] and they increase children's anxiety levels [4-7]. Both pain and anxiety are biological phenomena that are conditioned by psychological and social factors. Some of these indicator factors of pain perception are age, sex, and cognitive level of the patient [8,9] as well as the environment, culture and behavior of parents, guardians or professionals who assist them [7,10]. With respect to age, it is known that children at 3 years of age have memories of painful situations. These memories can be

negatively distorted if the child was distressed during the event [11].

On the other hand, the behavior of parents who accompany the child during the procedure and their stay in the emergency department can influence the perception and experience of the situation, which can generate great variability in the perceived intensity of pain and anxiety experienced by children [12-15]. The emotional response of the parents depends on the experience and the level of anxiety that they themselves feel during the stay in the emergency room and when the procedure is performed, sometimes requiring that health professionals establish strategies to prevent or control negative or blocking situations [1,15].

Measures aimed at reducing pain and the level of anxiety that invasive techniques generate in pediatric patients are of great importance in the hospital environment, especially in emergency departments. In the context of pediatric patients undergoing painful interventions, several studies conducted in Europe and America have demonstrated

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that the use of VR as a distraction technique is effective in reducing pain and the level of stress experienced by children [2,3,5,7,16-18].

As suggested by Baumgartner et al. [9], the brains of children process virtual experiences differently from adults. Therefore, young children may require different types of immersive experiences, as their sense of fantasy can become extremely real, especially for younger children. However, the existing literature shows that in the field of pediatric emergencies, this type of measure is not routinely implemented or evaluated [19,20], possibly due to uncertainty about the effectiveness of the measures to be implemented as well as their time commitment and potential cost [20]. Thus, there is a knowledge-to-practice gap in the use of virtual resources in invasive procedures in the pediatric population [3,21]. In addition, more studies using standardized experimental methodologies are required to provide evidence on the efficacy of the use of VR in the pediatric setting [17].

Therefore, the aim of this study was to evaluate the effectiveness of virtual reality to reduce pain and anxiety in pediatric patients during venipuncture procedure in emergency care and the behavioral response of their parents/companions.

## 2. Methods

### 2.1. Design

A quasi-experimental study was conducted with an intervention group (IG) and a control group (CG). The groups were generated on a temporal basis: the CG was formed in the first period of the study, and the IG was subsequently formed in the second period. The total sample consisted of 458 children who attended the pediatric emergency department of the University Hospital of Navarra, a reference center for Navarra, a region in northern Spain. The data were collected between September 2019 to April 2021.

### 2.2. Participants

The inclusion criteria in the study were as follows: boys and girls aged 2 to 15 years who required a venipuncture procedure or vascular access with peripheral venous catheter and whose legal guardians/parents agreed to participate in the study. The exclusion criteria were the presence of a structural affectionation in the facial or visual functional area of the patient, patients with a triage severity level of 1 (life-threatening emergency) and patients with more than one venous access attempt.

Patients were selected by consecutive sampling, and the sample size was calculated with the EpiInfo 7 program; the criteria established included a type I error of 0.05, a power of 80 % (error = 0.20) and a minimum difference to be detected of a 10 % improvement in the GI, starting from a presence of the result variable in the GC of 50 %. Based on this calculation, a sample of 458 records was considered sufficient, 229 subjects were recruited for the IG and 229 were recruited for the CG.

### 2.3. Intervention

The intervention consisted of performing the puncture technique using VR as a distraction mechanism for children. The professionals were previously trained to use the VR device.

In the IG, children utilized a VR device, which provided a fully immersive 3D computer-generated environment displayed in surround stereoscopic vision on an HMD that used 360° videos. Using the Oculus Go device, children visualized a sequence of four short scenes (80 s per scene) with various natural landscape environments and animals as well as audio stimulation with different animal sounds. They were a total of 3.20 min long and had sequential repetitions [Figs. 1-4].

For younger children, 2-4 years old, a foam rubber adapter was incorporated into the virtual reality glasses device that allowed the device to be correctly fixed, without pressing or disturbing the child's



Fig. 1. One of the scenes of virtual reality.



Fig. 2. One of the scenes of virtual reality.

facial area. Also, in older patients was the additional possibility of interacting with VR through a controller (or command) in four simple interactive games. The children put on the virtual eyewear with the help of their parents/companions before the procedure and kept them on until the end of the technique.

In the CG, the procedure was performed in accordance with standard practice. The usual process carried out in the pediatric emergency department for venipuncture and cannulation consisted of lying the patient on the stretcher, accompanied by the family member, who, together with another healthcare professional, ensured the fixation and immobilization of the patient. Traditionally, no additional distraction method was used.

### 2.4. Variables and measurement instruments

The sociodemographic variables measured were age, sex, and presence of a parent/companion. The clinical variables measured were severity at admission and type of technique (peripheral venous catheter cannulation or puncture for blood extraction). These variables were collected through the nursing reports registered in the computerized



Fig. 3. One of the scenes of virtual reality.



Fig. 4. One of the scenes of virtual reality.

clinical history of each child.

Outcome variables for the study included the level of pain experienced by the children, the level of anxiety observed in the children and the behavior of the parents. These variables were collected by direct observation and prospectively during the intervention process and after informing the patient and family members, as well as after signing the informed consent form.

To measure pain in the children, a visual analog scale with facial drawings, the Wong-Baker Faces Pain Scale [22], was used. It consists of six faces drawn with scores of 0, 2, 4, 6, 8 and 10, ranging from a smiling face for no pain (0 points) to a crying face for the worst pain possible (10 points). For young or noncooperative patients, pain was evaluated in addition with the standardized Face, Leg, Activity, Cry and Consolability (FLACC) scale [23,24]. On this scale, facial expression, leg mobility, activity, crying and the possibility of comforting the child are assessed on a scale of 0, 1 and 2 so that the total score of the scale is between 0 and 10. The numerical scores of Wong-Baker Faces Pain Scale recognize a categorization of pain into; 0 = relaxed and comfortable, 1–3 = mild discomfort, 4–6 = moderate pain and 7–10 = severe discomfort/pain. This categorization has also been compared and extrapolated for the numerical results of the FLACC scale. Finally, only all those cases concordant between the Wong-Baker and FLACC registry values were accepted as part of the sample.

To measure the anxiety level of children and the parents' behavior,

the Perioperative Adult and Child Behavioral Interaction Scale (PACBIS) was used, a method selected for its high validity and level of specificity for detecting stress in pediatric patients [25]. This scale has demonstrated excellent intraobserver reliability, (kw 0.62–0.94) and excellent correlation with other instruments assessing the same constructs.

The PACBIS scale contains four dimensions that correspond to four subscales. Each contains the most characteristic behaviors observable in the child or in the parents: The child's anxiety (Child distress), the child's coping with the situation (Child's coping), Parent behavior defined as reactive or blocking behavior (Parent Negative) and the parent's behavior defined as proactive (Parent Positive). Each dimension is scored from 0 to 2, and high scores would indicate maladaptive or stressful behaviors.

### 2.5. Data collection

The data related to the study variables were collected in situ by four nurses referred to the emergency department and pediatric short-stay hospitalization.

Data collection was performed during two time periods because of the beginning of the pandemic COVID-19. First, data from the CG were collected over a period of six months (September 2019–March 2020). Subsequently, after the nurses were trained in the research protocol (face-to-face training consisting of six hours and composed of one explanatory session of the protocol and two practical sessions for skills acquisition and familiarization with the VR device), the data were collected from the IG (November 2020–April 2021).

The data were gathered by a nurse researcher of the project through direct observation and recording of variables without interfering during the procedure. This professional was responsible for carrying out the assessment and direct treatment for the collection of data with the parents. To ensure uniform and systematic data collection, prior to the beginning of the study, the research team trained six nurses on the use of the scales for categorizing pain and anxiety and the data collection procedure. In addition, it was ensured through a trial prior to implementing the intervention that the six trained nurses who collected the data related to the variables under study did so homogeneously. Finally, the data collection process of the sociodemographic variables was carried out by a member of the research team of the project.

### 2.6. Data analysis

In the first instance, a descriptive analysis of the variables under study was carried out using the mean and standard deviation (SD) for quantitative variables and the frequency and percentage for qualitative variables.

Subsequently, an inferential test was performed to evaluate the homogeneity of the groups as well as to estimate the main differences between the CG and the IG in relation to the outcome variables. For this purpose, the chi square test was used to compare categorical variables, Student's *t* test was used to compare continuous variables, and the Mann–Whitney *U* test was used for ordinal variables.

Finally, several regressions were carried out. Ordinal logistic regressions were performed with the dependent variables pain, child distress, child coping and parent negative, with the variable "group" (IG and CG) introduced into the model as an independent variable and age as a control variable. Age was introduced in the model to demonstrate its lack of homogeneity in both groups. For the parent positive variable, a binary logistic regression was performed, as there were no subjects representing the third level of the variable (level 2). Likewise, the CG vs. IG group was introduced in the model as an independent variable, and age was included as a control variable. Statistical significance was set at 0.05. All analyses were performed with the statistical program SPSS v. 25.



2.7. Ethical considerations

The study was approved by the Clinical Research Ethics Committee of Navarra (CEICN) (Project 2018/52). The patients who were part of the study were informed verbally, along with the legal guardians/parents of the patients; all who freely consented to participate in the study were included. The signing of the corresponding informed consent form was performed by the legal guardians accompanying the pediatric patients.

3. Results

The CG was composed of 50.7 % boys and 49.30 % girls, with an average age of 10.7 years (SD: 2.). The IG was composed of 51.1 % boys and 48.5 % girls, with an average age of 7.9 years (SD: 4.1). In all cases, the children in the study were accompanied by a guardian or parent. Table 1 shows the sociodemographic and clinical variables. As can be seen, both groups are homogeneous except for the variables of age.

In relation to the outcome variables, the variable of pain and the anxiety (dimensions of the PACBIS scale: child distress, child coping, parent negative behavior and parent positive behavior), both the frequencies and the percentages of each level are presented in Table 2. For all of them, the Mann–Whitney U statistic revealed statistically significant differences between the two groups.

A total of 80.8 % of the subjects in the IG showed an absence of pain or mild pain compared to 57.4 % in the CG. In the assessment of anxiety, 12.2 % of the children in the CG obtained the maximum value of 2 for the child distress dimension, compared to 1.7 % in the IG. The negative response of the child on the child coping dimension was only present in the CG children at 4.8 % (p < 0.001).

The dimensions referring to the behavioral response of the accompanying family member showed maximum levels of block or negative response in 6.6 % of the CG compared to 0.9 % of the IG (p < 0.001).

Table 3 shows the results of the ordinal logistic regressions for the pain variables and the dimensions of the PACBIS for child distress, child coping and parent negative. For the parent positive variable, which did not reach its maximum value (2) in any case, a binary logistic regression was performed, which is presented in Table 4.

In all cases, the CG vs. IG group was introduced as an independent variable in the models, and age was included as a control variable.

A significant result with a protective effect was observed in the effect of using virtual reality in the IG both for the absence of pain (−4.12; 95 % CI: −4.85 to −3.40) and for the absence of distress or anxiety in the child (−1.71; 95 % CI: −2.24 to −1.17). VR with interactive play being appropriately employed in children over 5 years of age. The probability of presenting pain and anxiety in the CG patient was higher than the IG (p < 0.001).

The results obtained in the analysis of the child scoping subscale resulted in a majority for the highest levels of maladaptation or stress of the CG (4.8 %, 11), with the result of moderate stress being more prevalent in the CG (51.5 %,118) versus the IG (23.1 %, 53).

Table 1 Sociodemographic and clinical variables.

Variable	CG (n = 229)	IG (n = 229)	Chi <sup>2</sup> /t student (p value)
Sex			
Boy	50.7 (116)	51.5 (118)	0.035 (p = 0.852)
Girl	49.3 (113)	48.5 (111)	
Age mean (SD)	10.7 (2.6)	7.9 (4.1)	8.904 (p < 0.001)
Procedure			
Blood extraction	55 (126)	53.3 (122)	0.141 (p = 0.708)
Venous catheterization	45 (103)	46.7 (107)	

Table 2 Outcome variables.

Variable	LEVEL	CG% (n)	IG% (n)	Mann–Whitney p value		
Wong-Baker Faces Pain Scale	0	9.2 (21)	0	p = 0.042		
	1–3	48.2 (110)	80.8 (185)			
	4–6	29.4 (67)	18.2 (44)			
	7–10	13.2 (30)	0			
PACBIS	Child distress	0/2	69 (158)	54.6 (125)	p < 0.001	
		1/2	18.8 (43)	43.7 (100)		
		2/2	12.2 (28)	1.7 (4)		
	Child coping	0/2	72.1 (165)	48.5 (111)		p < 0.001
		1/2	23.1 (53)	51.5 (118)		
		2/2	4.8 (11)	0		
Parent Negative	0/2	83.4 (191)	64.6 (148)	p < 0.001		
	1/2	10 (23)	34.5 (79)			
	2/2	6.6 (15)	0.9 (2)			
Parent Positive	0/2	92.1 (211)	53.7 (123)	p < 0.001		
	1/2	7 (16)	46.3 (106)			
	2/2	0	0			

Table 3 Results of the ordinal regressions.

	Parameter	p value	95% CI	R2
No pain	−4.128	< 0.001	−4.853; −3.404	0.110
Level pain	0.038	0.882	−0.466; 0.543	
Moderate pain	2.022	< 0.001	1.441; 2.604	
CG	1.340	< 0.001	0.892; 1.788	
Age	−0.158	< 0.001	−0.217; −0.098	
Child distress 0	−1.711	< 0.001	−2.243; −1.179	0.203
Child distress 1	0.645	0.020	0.102; 1.188	
CG	0.547	0.019	0.090; 1.004	
Age	−0.275	< 0.001	−0.341; −0.210	
Child coping 0	−2.109	< 0.001	−2.684; −1.535	0.261
Child coping 1	1.639	< 0.001	0.915; 2.358	
CG	−0.103	0.654	−0.553; 0.347	
Age	−0.278	< 0.001	−0.344; −0.212	
Parent negative 0	−2.370	< 0.001	−3.017; −1.723	0.387
Parent negative 1	0.308	0.266	−0.289; 1.049	
CG	0.789	0.011	0.181; 1.396	
Age	−0.468	< 0.001	−0.566; −0.369	

Table 4 Results of the binary logistic regression for parent positivity.

	Exp (B)	p value	95% CI	R2
IG	3.983	< 0.001	2.028; 7.820	0.613
Age	0.593	< 0.001	0.529; 0.665	

Likewise, there was a significant reduction in the blocking response of the accompanying family member (−2.37; 95 % CI: −3.017 to −1.723) directly related to belonging to the IG (p < 0.001).

As shown in Table 3, the log odds show a moderate increase in the probability of suffering pain in patients in the control group (OR 1.340 (95 % CI 0.892 to 1.788), with the responses for child distress and child coping being very similar for both groups.

For the parent-positive variable [Table 4], the parents of the children treated in the IG had an “advantage” (greater odds) associated with their

positive behavior that was 3.98 times (odds ratio) higher than that of the parents of the children treated in the CG (95 % CI: 2.028 to 7.820).

#### 4. Discussion

The present study evaluated the effectiveness of using VR to reduce the perception of pain and anxiety in children having a painful procedure in emergency care and to promote a positive response in their parents.

The data obtained present a uniform division by comparison groups (CG and IG), with a very similar distribution by sex. The average age was somewhat higher in the CG (11 years vs. 8 years), with a significant difference compared with the intervention group and a direct influence on the level of anxiety according to the regression analysis. This aspect can be considered an intrinsic determining factor in pain assessment.

The results of the present study suggest that the use of VR as a distraction method is effective in children of different ages between 2 and 15 years. A better adaptation of VR with interactive play is seen in children older than 5 years, being a more immersive resource that requires a minimum age to allow its correct handling and effectiveness. Implementing this technology creates patient distraction that increases the probability that the patient will be cooperative.

The pain levels experienced by the pediatric patients during the procedure decreased in the IG, with the CG participants twice as likely to experience pain compared to IG participants. Therefore, these findings evidence that the use of VR is an effective distraction technique and that it reduces the perception of pain in pediatric patients in the emergency department. These results coincide with studies carried out in other countries in the context of pain management in pediatric patients during needle-related procedures, childhood vaccination and emergency care [3,4,7,19] or during procedures associated with pediatric hospitalization [2,8].

This work found a decrease in the level of anxiety experienced during an emergency in pediatric patients who are subjected to an invasive procedure, thanks to the use of the VR distraction technique during the procedure. Therefore, these results corroborate those of other recent studies in anxiety management using VR in pediatric general surgery [16] or in the field of pediatric emergencies [18].

In terms of the analysis of the parents' response during the procedure, the results of this study show a benefit in the attitudes presented by the parents, with a decrease in blocking or negative response in the IG parents. These results are important because it has been seen that a negative parental response is a conditioning factor for the elevated stress and anxiety felt by pediatric patients during an invasive procedure [7,12,13]. In this regard, this study provides new knowledge about the direct benefit of VR on the "reassuring" effect of the guardian or accompanying parent, showing that the child is four times less likely to have a reactive or negative attitude during the procedure. This action could be also bidirectional, as there is a decrease in anxiety in the child directly influenced by the positive response of their parents and the parents' low blocking response during the procedure is facilitated using distraction techniques in the pediatric patient. In line with these results, other studies have shown the efficacy of the use of distraction techniques as a mechanism for reducing the stress of accompanying family members [1,13,14].

With this, our study shows a beneficial effect of the use of VR in the reduction and control of the patient's pain, and the level of stress or anxiety experienced by the child during the procedure.

Finally, this study has some limitations. On the one hand, the fact that the IG was not formed in the same time as the CG could lead to some difference between the two groups. Although the main sociodemographic and clinical variables have been controlled to avoid the heterogeneity of both groups, there is always the probability of not having controlled any variable that implies a difference between the two groups. On the other hand, the literature shows that the morphology and tolerance to stimuli such as VR in children aged 2–6 years is different,

due to the differences in the maturational development of older ages. This fact could be improved by working on new comparative studies according to age ranges. However, our study tries to solve this aspect by adapting the VR device for better fixation and comfort in the smallest, being able to obtain data on the effect in this population. Lastly, this study deals with specific variables such as pain and anxiety, which may be different between different cultures. In this regard, this study has been carried out on a specific population of Spanish children. Therefore, we recommend developing multicenter studies to allow diverse population coverage and increased generalizability. Besides, we could recommend assessing the effectiveness of virtual reality in other diagnostic or therapeutic procedures that may generate similar situations of pain or stress in pediatric patients in emergency care.

#### 5. Conclusions

The use of VR in pediatric patients aged 2 years or more allows a significant reduction in the level of anxiety and pain experienced in children during a venipuncture procedure. Using VR during a blood extraction procedure or catheter cannulation lowers the probability of perceiving pain almost twofold compared to the traditional technique.

The probability of experiencing anxiety in pediatric patients during the puncture technique is almost 10 times lower in children who use a distraction system, such as VR, during the procedure. Moreover, the level of pain expressed by the child, together with the negative response or blocking of their parent/companion, have been identified as conditioning elements of the level of anxiety of the pediatric patient.

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#### CRedit authorship contribution statement

**Marta Ferraz-Torres:** Conceptualization, Methodology, Data curation, Writing – original draft. **Nelia Soto-Ruiz:** Data curation, Writing – review & editing. **Paula Escalada-Hernández:** Writing – review & editing. **Cristina García-Vivar:** Visualization, Writing – review & editing. **Leticia San Martín-Rodríguez:** Data curation, Formal analysis, Writing – review & editing.

#### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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