Effectiveness of Virtual Reality as a Distraction Technique for Pain During Intravenous Cannulation Among Pediatric Patients at Allama Iqbal Teaching Hospital Dera Ghazi Khan, Pakistan

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Abstract

Background: Peripheral intravenous (IV) cannulation in hospitalized children often causes procedural pain, fear, and anxiety. While pharmacological pain management exists, non-pharmacological methods like virtual reality (VR) provide effective audio-visual distraction during such procedures. This research evaluates VR's effectiveness in alleviating procedural pain in pediatric patients undergoing peripheral IV cannulation at Allama Iqbal Teaching Hospital, Dera Ghazi Khan, Pakistan.

Methods: A quantitative, quasi-experimental, design was conducted at Allama Iqbal Teaching Hospital, involving 120 pediatric patients aged 8–14 years needing peripheral IV cannulation. Participants were split into an intervention group (n = 60) receiving routine care and age-appropriate audiovisual distraction through a head-mounted VR system, and a control group (n = 60) receiving standard care. The VR content was selected to be suitable for children. Pain was assessed using the Wong-Baker FACES Pain Rating Scale during and after cannulation. Statistical analysis utilized a two-sided significance level of 0.05 and a power of 80%, with $p < .05$ indicating significance. Descriptive and inferential statistics were applied.

Results: In a study of 120 participants aged 8 to 14 years, 60 were assigned to a control group and 60 to an experimental group utilizing virtual reality (VR) during peripheral IV cannulation. The average age was 10.73 years, with 65 participants (54.2%) being boys. Successful cannulation was achieved on the first attempt at the dorsum of the hand. The experimental group experienced significantly lower pain scores: average pain during insertion was 2.53 in the VR group versus 9.00 in the control, and after insertion, scores were 1.93 versus 4.30, respectively. Mann–Whitney U tests indicated significant differences ($U = 8.00$, $p < .001$ for insertion; $U = 150.00$, $p < .001$ for after). Findings suggest VR effectively reduces procedural pain in pediatric patients, indicating its potential as a valuable nursing intervention for pain management.

Conclusion: Virtual reality effectively managed procedural pain during and after peripheral IV cannulation in pediatric patients, significantly lowering pain scores compared to routine care, making it an efficient nursing intervention.

Keywords: Pain, Distraction, IV Cannulation, Pediatric. Virtual Reality.

Introduction:

Pain is a distressing experience for hospitalized children, often leading to fear, anxiety, and resistance, particularly during needle procedures like venipuncture and IV cannulation (Sánchez-Caballero et al., 2024). These invasive procedures elicit significant pain and anxiety, exacerbated by children's limited understanding of their importance. Addressing this pain is critical, as pain management via medication carries risks. Consequently, non-pharmacological distraction techniques are gaining importance in pediatric nursing to improve patient experiences during such procedures (Tas et al., 2022). Behavioral indicators of procedural pain include crying, grimacing, withdrawal, tension, verbal resistance, and escape behaviors. Younger children particularly struggle to articulate their pain, necessitating careful behavioral assessment (Lluesma-Vidal et al., 2022; Tas et al., 2022). Therefore, developing effective pain prevention and management strategies is essential for enhancing child-centered nursing practices in pediatric care settings (Cho & Choi, 2021).

Pain experienced by hospitalized children during procedures like IV cannulation is significant due to their limited emotional and cognitive abilities, often leading to fear, anxiety, and resistance (Cáceres-Matos et al., 2024). Traditional pain management approaches, particularly pharmacological methods, come with risks, hence there's an increased focus on non-pharmacological distraction techniques in pediatric nursing. Proper assessment and management of procedural pain are crucial, as neglect can heighten fear and negatively impact perceptions of healthcare services. Children's pain depends on various factors, including age, emotional state, prior experiences, and adult responses. Needle-related pain is complex, involving both psychological and sensory experiences, which shape children's pain perception and their reactions to procedures (Gao et al., 2023). School-aged children can articulate their pain more clearly, but when medical focus prioritizes efficiency over comfort, their distress may be disregarded. Effective pain management during IV procedures is vital for a child's comfort, cooperation, and trust in medical personnel (Cozzi et al, 2021). This management must address both physiological and psychological aspects, utilizing local anesthetics effectively, and incorporating non-pharmacological methods like distraction, therapeutic communication, and parental presence. These techniques

can mitigate pain and enhance the overall experience during needle procedures. Research underscores the need for child-centered pain prevention and management techniques, particularly since children exhibit behavioral signs of pain that may necessitate tailored assessments, especially in younger patients with limited verbal expression abilities (Hasanah et al., 2024).

Distraction is an effective non-pharmacological pain management strategy for children during invasive procedures, helping shift focus away from pain. Its benefits arise from being easy to implement and cost-effective, making it suitable for quick procedures like venipuncture characteristics (Robinson et al., 2023). Efficacy varies with distraction type and child characteristics; younger children prefer colorful toys, while older ones engage more with games and videos. Active engagement significantly increases effectiveness, particularly in ages 6-12 years (Guillari et al., 2024). Distraction modifies cognitive and emotional pain responses, rather than eliminating the pain itself. The advent of digital technology has expanded distraction options, with tablets and video games offering engaging experiences, leading to reductions in self-reported and observed pain. Interactive games that require participation are particularly effective (Sajeev et al., 2021; Robinson et al., 2023). Virtual reality (VR) offers immersive distraction, further enhancing engagement and reducing awareness of medical procedures (Sánchez-Caballero et al., 2024). Its pain-relieving effectiveness is linked to attentional diversion, though it does not diminish the physiological aspects of procedures (Teh et al., 2024). VR may also reduce anxiety, which in turn alleviates pain perception. Initial studies indicate positive outcomes with VR in pediatric settings (Cáceres-Matos et al., 2024, Gold et al., 2021). It standardizes distractive measures, improving trial fidelity while remaining adaptable for developmental needs. Ensuring safety and acceptability is critical, as even non-invasive methods can have side effects. Despite promising results, further country-specific research in Pakistan is needed to confirm VR's practicality and effectiveness in local healthcare contexts (Wang et al., 2023). To determine the effectiveness of virtual reality as a distraction technique for reducing pain during intravenous cannulation among pediatric patients at Allama Iqbal Teaching Hospital, Dera Ghazi Khan, Pakistan.

Methodology

3.1 Research Design

Quasi-experimental, non-equivalent control group post-test only design was adopted in order to test the effectiveness of virtual reality (VR) as a non-pharmacological distractor for reduction of procedural pain during peripheral intravenous (IV) cannulation among pediatric patients in Allama Iqbal Teaching Hospital, Dera Ghazi Khan, Pakistan. Quasi-experimental design is suitable in this case since there was deliberate introduction of intervention to one group and comparison group received standard care but participants was not be randomly allocated into two groups. Two groups were considered for the study including: Intervention group routine care plus age-appropriate VR distraction and Control group routine/standard care without VR distraction.

The study took place in the Pediatric Department of Allama Iqbal Teaching Hospital, Dera Ghazi Khan, Punjab, Pakistan. Allama Iqbal Teaching Hospital is a teaching hospital which offers health care services to pediatric patients from Dera Ghazi Khan and surrounding areas. The pediatric clinical setting is a proper setting for conducting the study because peripheral intravenous cannulation is carried out among those children who are required to go for diagnostic investigation, intravenous medications or fluids or any other treatment. Data was collected from an area where peripheral IV cannulation is routinely performed.

The study participants were consisting of pediatric patients between the ages of 8 and 14 years old requiring peripheral intravenous cannulation during their admission/treatment at Allama Iqbal Teaching Hospital, Dera Ghazi Khan. The choice of an age range of 8 to 14 years is appropriate for the adopted subjective self-report method of pain assessment as children in this age range have the capability of understanding and reporting pain.

3.4 Sample Size

Sample size calculation was conducted on the basis of two-sided significance level of 5% (α = 0.05), statistical power of 80% (1−β = 0.80), and medium effect size of 0.52 [13].

The sample size for each group was calculated according to the formula:

$$\boldsymbol{n = \frac{2(Z_{\alpha/2} + Z_{\beta})^2}{d^2}}$$

Where:

$n =$ required sample size per group

$Z_{\alpha/2} =$ standard normal deviate at 95% confidence level $= 1.96$

$Z_{\beta} =$ standard normal deviate at 80% power $= 0.84$

$d =$ standardized effect size

The number of subjects per group was determined by the following equation: With the above considerations, the estimated minimum number of subjects for the study is about: 126 subjects. But since the actual number of subjects due to practical limitations and availability of subjects at the time of data collection is 120, the number of subjects was finally determined as 120. The number of subjects in each group was equal: Number of intervention group = 60 Number of control group = 60 Total number of subjects = 120 subjects.

For recruitment of participants, the consecutive sampling approach would be employed. With consecutive sampling, all those pediatric patients who fit the set inclusion criteria and are available during the data collection period would be recruited consecutively until 120 participants are recruited. Participants would first be screened based on the inclusion criteria prior to being recruited into the study would be provided to parents or legal guardians, while an explanation of the procedure would be provided to the children. It is appropriate to use the consecutive sampling approach in a clinical study that targets a specific hospital population since the researcher can recruit participants as they become available.

Eligible subjects were recruited consecutively and assigned into one of the two study groups based on the predetermined study allocation process. The two groups would comprise the following: *Intervention Group:* Participants would receive: Standard care + VR distraction. *Control Group:* Participants would receive: Standard care without VR distraction. Since the design of the study is quasi-experiment, the intervention and control groups were viewed as non-equivalent groups. Demographic and other clinical data were thus be collected and compared across groups as a means of evaluating comparability.

Subjects assigned to the control group would receive routine/standard clinical care offered by the hospital for peripheral IV cannulation. No VR intervention would be done. The IV cannulation was done by well-trained medical staff according to the routine clinical procedure in the hospital. Pain assessment was done through the same Wong-Baker FACES scale and at the same predetermined assessment points as the intervention group [14]. It is important to have a similar pain assessment procedure for both groups since the only difference between them would be the VR intervention. To ensure consistency, the researcher used a standardized VR intervention protocol. What was measured: Same VR headset, same age-appropriate content loaded onto the VR headset beforehand, same approximate time of intervention, VR started just prior to cannulation, VR continued during cannulation, same instructions to the participant, same pain assessment process, and recording of any interruption/technical difficulties. In case of intolerance of the headset by the participant or any discomfort experienced by the participant during the intervention, the VR therapy was stopped.

Inclusion Criteria

Participants were included if they: Are aged 8–14 years, require peripheral intravenous cannulation as part of routine clinical care, are conscious, alert, and able to communicate, are able to understand the instructions required for using the Wong-Baker FACES Pain Rating Scale. Moreover, the participants were able to see and hear sufficiently to participate in the VR intervention, have not previously participated in the current study, have a parent/legal guardian willing to provide informed consent, and are clinically stable enough to participate in the distraction intervention.

Exclusion Criteria

Participants were excluded if they: Have altered consciousness or significant cognitive impairment, visual or hearing impairment that prevents reliable self-report, and that prevents effective use of the VR intervention, have a condition that prevents safe use of a head-mounted device. Those participants were also excluded that require emergency IV access where delaying or modifying the procedure for research purposes could compromise care, have severe acute pain unrelated to the IV cannulation procedure immediately before the procedure, have received a pharmacological analgesic immediately before cannulation, have previously experienced significant adverse effects or intolerance associated with VR, and decline participation or withdraw assent/consent.

Virtual Reality Intervention and its administration

Intervention group participants were exposed to appropriate-age related audiovisual virtual reality (VR) distraction through a head-mounted virtual reality system. This intervention is grounded on the theory of attention diversion/distraction, whereby immersion with audiovisual content is expected to shift the child's attention away from the procedure associated with the needle. The VR headset for the intervention group was placed just before the peripheral intravenous cannulation of the participant. The participant was instructed about the VR equipment and its chosen content. The procedure was performed as follows (see figure 1):

Preparation → Eligibility criteria of the participants → Informed consent from the guardian → Pre-test data (baseline data) → Child introduced to VR device → start of age-related VR audiovisual → **Peripheral IV cannulation performed** → continuing VR content during cannula procedure → Pain assessed during the predefined procedural point → IV cannulation completed

→ Pain assessed immediately after cannulation → Data recorded

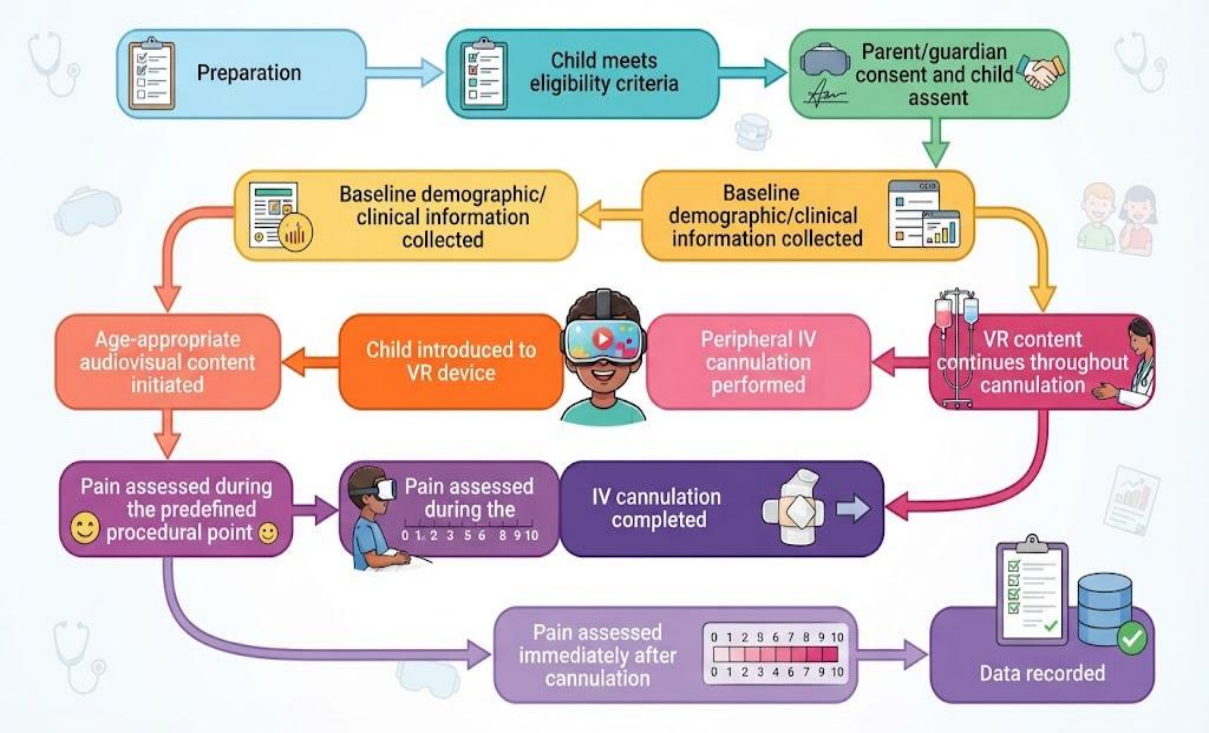


Figure 3.1: Steps from base line to data recording

The VR content was continued while the IV cannula is inserted so that the distraction is active during the painful stimulus.

A structured data-collection form was used. It was consisting of two main sections.

Section one contains information such as: Age, gender, relevant clinical information, previous IV cannulation experience, number of cannulation attempts, and other relevant characteristics specified in the protocol

In section 2 **the** procedural pain was measured through the Wong-Baker Faces Pain Rating Scale (see the figure 2). The Wong-Baker Faces Pain Rating Scale was designed as a self-report tool aimed at assisting children to articulate their pain. The Wong-Baker Faces official foundation describes the scale as a self-reporting instrument that ought to be chosen by the patient, and not rated by a parent, nurse, or any other person. The scale comprises of six faces indicating different levels of pain from 0= No hurt to 10 = Hurts Worst [14].

The pain assessment process was as follows: At the time of IV insertion, using the pre-planned observation point in the protocol, and Immediately after IV insertion. The child was choosing their pain intensity independently. The chosen option was recorded immediately on the study data collection form. Since the Wong-Baker FACES Pain Rating Scale is a self-report tool, the researcher was not choosing an option for the child.



Figure 3.2: Wong-Baker FACES Pain rating scale

3.10.3 Validity and Reliability of Instruments

Wong-Baker FACES Pain Rating Scale is one of the widely recognized pain instruments, a picture scale that can be used in pediatrics. It gives children the ability to express how much pain they are feeling through a facial expression rather than giving an explanation in words. The validity of the Wong-Baker FACES scale was performed in 120 patients, ranging in age from 8 to 17 years, by Garra et al. (2010) [15]. In their study, the authors compared scores on the Wong-Baker FACES scale (WBFPRS) with the 100-mm Visual Analogue Scale (VAS). The excellent Spearman correlation coefficient was calculated and equaled ρ = 0.90 (95% CI [0.86, 0.93]) between the two tools, which proves a high degree of convergent validity. Mean VAS scores were also growing consistently in the range of six categories of the Wong-Baker scale, about 17 mm between categories [15].

3.11 Data Collection Procedure

The data collection procedure was complete in three stages through systematic manner (see figure 3).

Stage 1: Pre-Intervention Phase: In this stage the patient was identified and screen for eligibility and informed consent from guardian/ parents was taken, and base line data and clinical data was collected as required. The base line data was collected from both control and intervention groups.

Stage 2: Intervention Phase: In this stage the n-60 participant of control group received standard protocol of IV cannulation while, the intervention group received the VR distraction intervention.

Stage 3: The child was asked to self-report the pain using the Wong-Baker FACES scale during the predetermined point and immediately post-completion of cannulation. Recording of data: Pain score and other procedural data was recorded, from both interventional and control group as post-test data. The code names were recorded instead of name.

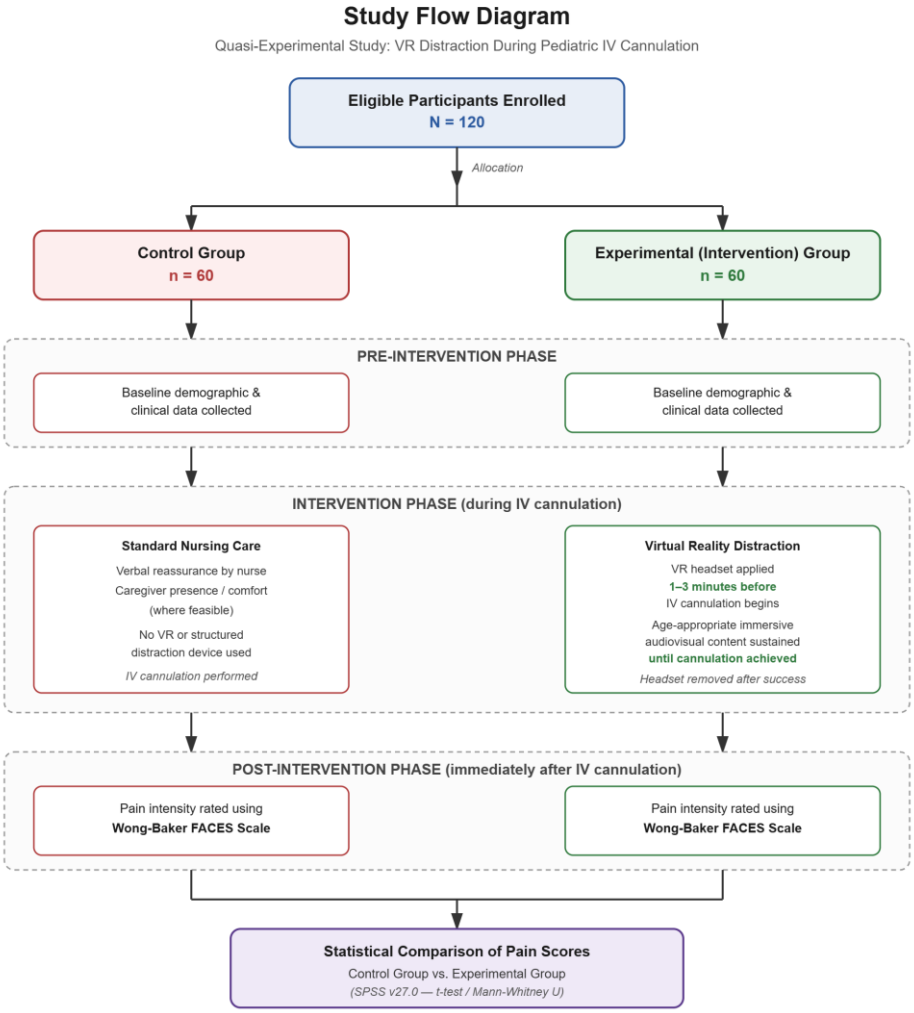


Figure 3: Flow chart of the study

3.12 Data Analysis

Data entry and data analysis were done using appropriate statistical software like SPSS. Descriptive statistics was used to describe the characteristics of participants. For categorical variables as frequency and percentages. For

continuous variables, Mean and standard deviation were calculated. As Inferential statistics: Independent-samples t-test was employed for the comparison of mean pain scores between groups. In case that the normality assumptions failed: Mann-Whitney U test could be performed. Categorical variables would be compared using through Chi-square test and Fisher's exact test

Ethical considerations

The study was cleared by the appropriate institutional/ethical review committee. Permission was granted to conduct the study from the administration of Allama Iqbal Teaching Hospital, Dera Ghazi Khan for data collection. As the participants are children, special consideration has been given to obtaining informed consent and assent. The following ethical principles were followed:

Written informed consent was obtained from parents or guardians, and children were informed about the study using appropriate language. The participation was voluntary, so the subjects could withdraw without any adverse effects. The participants' names were not included in the database, and the codes were used instead to ensure confidentiality. The data were collected in a clinical setting to guarantee privacy. The active distraction is an evidence-based method for decreasing distress caused by needles. The virtual reality was used as a non-pharmacological technique to manage clinical care, and the content was pre-tested and appropriate for children. The recommendations for using VR include the use of appropriate content for the age of the subjects and the need to maintain privacy (Marks et al., 2025).

Data Analysis

This chapter discusses the data analysis results of 120 pediatric patients who had intravenous cannulation at Allama Iqbal teaching hospital Dera Ghazi Khan. The findings are presented to provide the demographic and clinical characteristics of the patients, compare baseline demographics of patients in the control and experimental groups, and evaluate the impact of virtual reality distraction on pain during and following insertion of intravenous. Descriptive statistics were employed to describe the participant characteristics and the variables of the study followed by an inferential analysis to examine differences between the groups on pain outcomes. To compare the pain variables, the assumption of normality was violated, and, therefore, non-parametric testing was used. The chapter thus shifts from general description of the sample to outcome analysis to provide a clear picture whether or not virtual reality was an effective distraction tool to reduce pain among the children patients when undergoing intravenous cannulation.

4.1 Sociodemographic data of the participants

Table 4.1 presents the demographic and clinical characteristics of the 120 pediatric participants included in the study. Age distribution indicated that age 12 years had the highest numbers of children (23.3%) followed by age 8 years (20.0%). The lowest age group was 14 years with 8 (6.7%) participants. This means that the sample was distributed widely in the age band of interest (8 to 14 years) and there was higher representation in middle childhood. The gender-wise distribution of respondents revealed that there were more male respondents as compared to female respondents. A total of 65 children (54.2%) were male, whereas 55 children (45.8%) were female. Most of the children were accompanied by their fathers (101 cases, 84.2%) while the mothers accompanied only 19 children (15.8%). This indicates that many of the children included in this study had fathers who were the main accompanying caregiver for the child.

According to the diagnostic profile, fever was the most prevalent (n = 37, 30.8%). The next most commonly reported causes were thalassemia with 17 children (14.2%) and chest infection with 16 children (13.3%). Eight (6.7%) patients had pneumonia and 6 (5.0%) had a urinary tract infection, respiratory tract infection and dog bite, respectively. Lower percentage of children were admitted to asthma, blood transfusion needs, food poisoning, diabetic ketoacidosis, diarrhea, hemophilia, nephrotic syndrome and snake bite. This indicates that some children in the sample had a number of medical conditions for which they needed intravenous access; fever and thalassemia related presentations were more prevalent than other presentations. No one had ever had an IV placed, which was another characteristic that was 100% uniform in the sample. Likewise, intravenous cannulation was done on all subjects (120 (100.0%)), at the dorsum of the hand. There was also no difference in the nurse experience, with all procedures performed by 1-3 year experienced nurses. All of these features indicate that the procedure itself was standardized to a large degree throughout the study.

Lastly, there was an even distribution of numbers across the sample in the two study arms. The control group had 60 subjects (50.0%) and the experimental group 60 subjects (50.0%). This equal allocation allowed for equal comparison between the groups of children receiving standard care and those receiving the virtual reality intervention during IV placement (see table1).

Table 1: Demographic and Clinical Characteristics (N = 120)

Variable	Category	Frequency (n)	Percentage (%)
Age Group (years)	8	24	20.0
	9	16	13.3
	10	13	10.8
	11	15	12.5
	12	28	23.3
	13	16	13.3
	14	8	6.7
Gender	Male	65	54.2
	Female	55	45.8
Accompanying Person	Mother	19	15.8
	Father	101	84.2
Diagnosis	Asthma	4	3.3
	Blood Transfusion	4	3.3
	Chest Infection	16	13.3
	Diabetic Ketoacidosis	2	1.7
	Diarrhea	2	1.7
	Dog Bite	6	5.0
	Fever	37	30.8
	Food Poisoning	2	1.7
	Hemophilia	2	1.7
	Nephrotic Syndrome	2	1.7
	Pneumonia	8	6.7
	Respiratory Tract Infection	6	5.0
	Snake Bite	2	1.7
	Thalassemia	17	14.2
	Thalassemia / Blood Transfusion	4	3.3
	Urinary Tract Infection	6	5.0
Previous IV Cannulation	No	120	100.0
Site of IV Cannulation	Dorsum of Hand	120	100.0
Nurse Experience	1–3 Years	120	100.0
Study Group	Control Group	60	50.0
	Experimental Group	60	50.0

2 Descriptive Statistics of continuous variables

Table 2 presents the descriptive statistics of the continuous study variables for the 120 participants included in the analysis. The ages of the children ranged between 8 and 14 years with a mean age of 10.73 years and a standard deviation of 1.94 years, suggesting that the majority of the children in the age range were lumped into middle childhood in the selected range of ages. This indicates that the sample was fairly representative of the targeted age group; but there was a slight weighting to the younger age group. The number of IV tries was also the same for all the participants, minimum, maximum and mean value was 1.00 and no difference was seen. This represents the first attempt cannulation was successful in all children, which helped to provide consistency in procedures throughout the study. Only the experimental group had a distraction time recorded and it varied between 1 and 4 minutes, with the mean being 3.07 minutes and standard deviation being 0.86. This indicates that the VR intervention was generally used for brief yet long enough duration during the cannulation procedure. In terms of main outcome measures, pain at IV insertion was measured by participants on a scale of 0-to-10, with the mean score being 5.77 and standard deviation being 3.61, thus showing significant variation in perceived pain. Post IV insertion pain (confirmed by ankle score 0–6) was lower than IV insertion pain, with a mean score of 3.12 (S.D. 1.46) compared to a mean score 4.12 (S.D. 2.12) with a range of 0 to 6. Overall, these descriptive findings show that while the study sample was relatively uniform in terms of procedural attempts, there was marked variability in pain perception, which supported the need for comparative analysis between the control and experimental groups (see table 2).

Table 2: Descriptive Statistics of Continuous Study Variables (N = 120)

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Age	120	8.00	14.00	10.73	1.94
Number of Attempts	120	1.00	1.00	1.00	0.00
Duration of Distraction*	60	1.00	4.00	3.07	0.86
Pain During IV Insertion	120	0.00	10.00	5.77	3.61
Pain After IV Insertion	120	0.00	6.00	3.12	1.46

*Duration of distraction was applicable only to the experimental group (n = 60).

Baseline Comparison Between Control and Experimental Groups

Table 3 presents the baseline comparison of selected demographic characteristics between the control and experimental groups. The distribution of gender did not differ significantly between the two groups, as male participants accounted for 29 (48.3%) in the control group and 36 (60.0%) in the experimental group, while female participants accounted for 31 (51.7%) and 24 (40.0%), respectively; this difference was statistically non-significant ($\chi^2 = 1.645$, $p = 0.200$). Similarly, no significant difference was found in terms of accompanying person, where mothers accompanied 11 children (18.3%) in the control group and 8 children (13.3%) in the experimental group, while fathers accompanied 49 children (81.7%) and 52 children (86.7%), respectively ($\chi^2 = 0.563$, $p = 0.453$). These findings indicate that the two groups were comparable at baseline with respect to the demographic variables assessed (see table 3).

Table 3: Baseline Comparison of Demographic Characteristics Between Control and Experimental Groups (N = 120)

Variable	Category	Control Group n (%)	Experimental Group n (%)	χ^2	p-value
Gender	Male	29 (48.3)	36 (60.0)	1.645	0.200
	Female	31 (51.7)	24 (40.0)		
Accompanying Person	Mother	11 (18.3)	8 (13.3)	0.563	0.453
	Father	49 (81.7)	52 (86.7)		

Mean Age Between Control and Experimental Group

Table 4 presents the comparison of mean age between the control and experimental groups. The mean age of participants in the control group was 10.70 years (SD = 1.98), while the mean age in the experimental group was 10.75 years (SD = 1.92). The independent-samples t-test showed that this difference was not statistically significant ($t = -0.141$, $p = 0.888$). This indicates that both groups were comparable in terms of age at baseline, and age was unlikely to have influenced the difference in pain outcomes observed between the two groups.

Table 4: Comparison of Mean Age Between Control and Experimental Groups (N = 120)

Variable	Study Group	N	Mean	SD	t-value	p-value
Age	Control Group	60	10.70	1.98	-0.141	0.888
	Experimental Group	60	10.75	1.92		

Pain Scores by Study Group

Table 5 presents the descriptive statistics of pain scores during and after intravenous insertion for participants in the control and experimental groups. A marked difference was observed between the two groups in both pain measures. During intravenous insertion, the control group reported a much higher mean pain score of 9.00 (SD = 1.13), with a median of 10.00, whereas the experimental group reported a substantially lower mean pain score of 2.53 (SD = 1.94), with a median of 2.00. The pain scores in the control group ranged from 6 to 10, while those in the experimental group ranged from 0 to 6, indicating that children who received the virtual reality intervention experienced notably lower pain during the procedure. A similar pattern was found for pain after intravenous insertion. The control group had a mean post-insertion pain score of 4.30 (SD = 0.87), with a median of 4.00, whereas the experimental group had a lower mean score of 1.93 (SD = 0.82), with a median of 2.00. The observed ranges further reflected this difference, with control group scores extending from 2 to 6 and experimental group scores from 0 to 4. Overall, these descriptive findings suggest that participants in the

experimental group consistently reported lower pain levels both during and after intravenous insertion compared with those in the control group (see table 5).

Table 5: Descriptive Statistics of Pain Scores by Study Group (N = 120)

Variable	Study Group	N	Mean	SD	Median	Minimum	Maximum
Pain During IV Insertion	Control Group	60	9.00	1.13	10.00	6.00	10.00
	Experimental Group	60	2.53	1.94	2.00	0.00	6.00
Pain After IV Insertion	Control Group	60	4.30	0.87	4.00	2.00	6.00
	Experimental Group	60	1.93	0.82	2.00	0.00	4.00

4.6 Tests of Normality for Pain Scores by Study Group

Table 6 presents the results of the normality tests for pain during and after intravenous insertion in both the control and experimental groups. For pain during intravenous insertion, both the Kolmogorov-Smirnov and Shapiro-Wilk tests were statistically significant in the control group and in the experimental group ($p < 0.001$), indicating that the distribution of scores departed significantly from normality. A similar pattern was observed for pain after intravenous insertion, where both normality tests were also significant in the two groups ($p < 0.001$). These findings showed that the pain variables were not normally distributed in either group. Therefore, the assumption of normality required for parametric testing was not met, and a non-parametric test, namely the Mann-Whitney U test, was used to compare pain scores between the control and experimental groups (see table 6).

Table 6: Tests of Normality for Pain Scores by Study Group (N = 120)

Variable	*Study Group*	*Kolmogorov-Smirnov*	*p-value*	*Shapiro-Wilk*	*p-value*
Pain During IV Insertion	Control Group	0.344	< 0.001	0.706	< 0.001
	Experimental Group	0.241	< 0.001	0.868	< 0.001
Pain After IV Insertion	Control Group	0.435	< 0.001	0.623	< 0.001
	Experimental Group	0.432	< 0.001	0.564	< 0.001

Comparison of Pain Scores Between Control and Experimental Groups

Table 7 presents the comparison of pain scores between the control and experimental groups using the Mann-Whitney U test. A highly significant difference was found in pain during intravenous insertion between the two groups ($U = 8.000$, $Z = -9.604$, $p < 0.001$). The control group had a substantially higher mean rank of 90.37, whereas the experimental group had a much lower mean rank of 30.63, indicating that children in the control group experienced significantly greater pain during the procedure than those who received the virtual reality intervention. A similarly significant difference was also observed in pain after intravenous insertion ($U = 150.000$, $Z = -9.418$, $p < 0.001$). The mean rank for post-insertion pain was 88.00 in the control group and 33.00 in the experimental group, again showing lower pain levels among participants in the experimental group. These findings demonstrate that virtual reality distraction was effective in significantly reducing pain both during and after intravenous cannulation among pediatric patients.

Table 7: Comparison of Pain Scores Between Control and Experimental Groups Using Mann–Whitney U Test (N = 120)

Variable	Study Group	n	Mean Rank	Mann–Whitney U	Z	p-value
Pain During IV Insertion	Control Group	60	90.37	8.000	-9.604	< 0.001
	Experimental Group	60	30.63			
Pain After IV Insertion	Control Group	60	88.00	150.000	-9.418	< 0.001

	Experimental Group	60	33.00

Correlation of Pain Scores with Selected Continuous Variables

Table 4.8 presents the correlation of pain scores with selected continuous variables. A strong positive correlation was found between pain during intravenous insertion and pain after intravenous insertion ($r = 0.817$, $p < 0.001$), indicating that children who reported higher pain during the procedure also tended to report higher pain after the procedure. In contrast, age showed no significant relationship with pain during intravenous insertion ($r = -0.004$, $p = 0.962$) or pain after intravenous insertion ($r = 0.014$, $p = 0.876$), suggesting that pain scores were not influenced by the age of the participants within the studied range. Similarly, duration of distraction did not show a significant association with pain during intravenous insertion ($r = -0.103$, $p = 0.435$) or pain after intravenous insertion ($r = 0.102$, $p = 0.436$). Overall, these findings indicate that the strongest association existed between the two pain measures themselves, while age and duration of distraction were not significantly related to pain outcomes.

Table 8: Correlation of Pain Scores with Selected Continuous Variables (N = 120)

Variable	Pain During IV Insertion, r (p-value)	Pain After IV Insertion, r (p-value)
Pain After IV Insertion	0.817 (0.000)	—
Age	-0.004 (0.962)	0.014 (0.876)
Duration of Distraction*	-0.103 (0.435)	0.102 (0.436)

Note: Pearson correlation was applied to examine the relationship of pain scores with selected continuous variables. Duration of distraction was available only for the experimental group (n = 60). Number of attempts was excluded from the final correlation table because it was constant for all participants and no correlation could be computed.

Discussion

This study involved an experimental design focusing on the pediatric population aged 8 to 14 years. The most represented age groups were 12 years (23.3%) and 8 years (20.0%), while ages 9 and 13 accounted for 13.3% each. The sample comprised predominantly male participants (54.2%), which provided a balance in gender representation. Caregiver distribution revealed that fathers were the primary caregivers (84.2%), which might influence children's emotional responses during painful procedures. The study investigated the impact of virtual reality (VR) on pain perception during intravenous (IV) cannulation, emphasizing the importance of parental presence, especially during venipuncture interventions. Clinical diagnoses were varied, with fever being the most common diagnosis (30.8%), followed by thalassemia (14.2%), and lung infection (13.3%). Notably, 120 children had no prior history of intravenous cannulation, which makes the findings particularly relevant for first-time experiences rather than for those with previous exposure to IV procedures. All cannulation was performed on the dorsum of the hand by nurses with 1–3 years of experience, ensuring consistency in the study's methodology. The study's demographic distribution indicates that age is a vital component for understanding pain levels and anxiety during medical procedures. The findings align with previous research indicating younger children benefit more from VR interventions. Gender also serves as a key variable, clarifying the characteristics of the participants [16]. The presence of caregivers can significantly affect children's coping responses to pain, corroborated by literature highlighting parental roles in pediatric medical settings. Having no previous cannulation history among participants contributes to a standardized baseline for assessing the effects of VR. Additionally, standardizing the cannulation site across participants helps control for variability in pain experience. The even split of participants into control and experimental groups (50% each) allows for solid comparisons of VR intervention effectiveness. Comparatively, the study supports existing literature that investigates VR in pediatric settings but differentiates itself through the inclusion of demographic and procedural standardizations conditions [17]. While previous research has shown that VR significantly alleviates pain and anxiety in children during procedures, differences in participant demographics, sample sizes, and procedural environments can yield varied outcomes, as seen in conflicting studies [18]. This study’s unique characteristics, such as strong paternal representation among caregivers and a specific range of clinical diagnoses, might make its findings contextually significant and suggest further research is necessary to generalize results across diverse populations. The implications highlight the importance of standardized procedural techniques and specific caregiver dynamics in the context of pediatric pain management; the research reinforces the potential benefits of VR technology in easing pediatric procedural

discomfort while contributing to the broader discourse on effective pain management strategies in clinical environments.

The study highlighted significant differences in pain levels experienced by children during intravenous cannulation between control and experimental groups. The control group, receiving standard care, reported a mean pain score of 9.00 (SD = 1.13), while the experimental group utilizing virtual reality (VR) distraction reported a mean score of 2.53 (SD = 1.94). A Mann–Whitney U test indicated a statistically significant difference ($U = 8.000$, $Z = -9.604$, $p < .001$), suggesting that VR substantially alleviated pain during needle insertion compared to routine care. The additional checks for baseline characteristics, such as age and gender, confirmed that differences were attributable to VR intervention.

These findings align with existing literature on the benefits of immersive distraction techniques for reducing pain in pediatric patients undergoing vascular-access procedures. Past studies, including those by Goldman and Behboudi (2021) and Schlechter et al. (2021), also reported advantageous outcomes when VR was employed in clinical settings, even amidst time constraints [19, 20]. The current research included a specific demographic of children aged 8–14 years from a Pakistani public-sector teaching hospital, reinforcing VR's potential as an effective, non-pharmacological intervention in routine invasive procedures. The observed difference in pain scores might relate to VR's immersive qualities, which distract children from the procedure by blocking visual exposure to distressing cues. Instead of fixating on the cannula and procedural noises, VR provides engaging audiovisual stimuli, occupying the child's attention and minimizing pain perception. Evidence suggests that environmental changes through VR contribute effectively to lowering procedural pain responses [21]. The controlled conditions of the study likely strengthened the results, as all participants had no previous cannulation experiences, successful insertions were achieved on the first attempt, and nurses exhibited similar skill levels. Notably, the chosen age range allowed participants to engage effectively with the VR content and accurately report their pain levels, enhancing the findings' applicability among young adolescents..

Results from the current study indicate that children who underwent intravenous (IV) cannulation with virtual reality (VR) distraction experienced significantly lower post-insertion pain scores compared to those who did not receive VR. The control group's mean pain score was 4.30 (0.87), while the experimental group reported a mean score of 1.93 (0.82), yielding a statistically significant difference ($U = 150.000$, $Z = -9.418$, $p < .001$). The findings suggest that children exposed to VR distraction not only experienced less pain at the moment of needle insertion but also reported ongoing reduced discomfort following the procedure.

These results align with recent pediatric studies, which show that immersive distraction significantly lessens the sensory and emotional impact of needle-related procedures. For example, Gerçeker et al. (2021) demonstrated that VR can improve responses to invasive procedures in pediatric hematology-oncology patients, and Hundert et al. (2022) found VR reduced procedural pain and enhanced coping during subcutaneous port access in children and adolescents [22, 23]. Similarly, Savaş et al. (2024) reported that a biofeedback-based VR game decreased pain, fear, and anxiety during needle insertion [24]. Although these studies focused on various vascular access methods, they collectively confirm VR's positive influence on not only peak pain but also immediate recovery from painful procedures. One reason for lower post-insertion pain scores could be the diversion of emotional and attentional focus away from the discomfort experienced during cannulation. Even after a needle is secured, children might continue focusing on pain at the insertion site or recalling the painful experience. VR allows children to perceive the procedure as less threatening, which may result in reduced pain perception afterward. Piskorz et al. (2020) also found mobile VR to lower needle pain and stress, emphasizing the broader impact of immersion on the pain response, rather than just the immediate puncture pain [25]. The study’s findings benefit from standardized conditions such as the absence of previous cannulation experiences and similar insertion sites, procedures, and nursing expertise. The age group of 8-14 years was suitable for effective pain reporting and highlights the significance of using developmentally appropriate methods in pain assessment. However, the study's limitations include the single-time pain assessment and specific participant demographics, which may not reflect trends across younger populations or chronic illness patients. Despite these limitations, the findings suggest VR can foster a less painful and calmer post-cannulation experience, enhancing children’s cooperation and overall hospital care.

The study found that virtual reality (VR) is an effective distraction tool for reducing pain during IV insertion in children. The experimental group reported a mean pain score of 2.53 (SD = 1.94) during insertion compared to 9.00 (SD = 1.13) in the control group. Post-insertion, the mean pain score was significantly lower in the experimental group (1.93 ± 0.82) compared to the control group (4.30 ± 0.87). Mann–Whitney U tests revealed significant differences in pain experienced during ($U = 8.000$, $Z = -9.604$, $p < .001$) and after insertion ($U = 150.000$, $Z = -9.418$, $p < .001$). The results indicate that VR leads to a substantial reduction in pain associated with pediatric IV procedures. This aligns with recent randomized controlled trials (RCTs) indicating that VR effectively lowers pain and anxiety during pediatric vascular-access procedures [13]. A pragmatic trial suggested

VR could be integrated into pediatric clinical workflows without significant disruption, supported by multicenter evidence demonstrating VR's effectiveness in alleviating pain and distress from needles [26]. Review-level evidence shows that VR effectively reduces fear and pain during needle procedures in children [6, 27].

The study attributes VR's success to its immersive sensory engagement, which substitutes the clinical environment with a captivating audiovisual experience, thereby reducing children's awareness of pain. Despite limitations, such as the homogeneity of the sample from a single hospital and specific age range, the study underscores the value of nurse-led VR interventions in minimizing pain during IV cannulation in children. It highlights the need for integrating VR into an evidence-based, atraumatic pediatric care framework. Nonetheless, VR effectiveness may vary based on factors like headset type, content, and demographic variables [2, 28].
Children using VR reported less pain during IV insertion than those given standard care, matching earlier findings on VR easing pediatric procedural discomfort and anxiety [21, 29]. Broader reviews confirm this effect but note it varies by age and intervention type [30]. VR's immersive quality appears to outperform simpler distractions like cartoons or tablet game [31]. Still, VR's benefit isn't universal across all ages, procedures, or settings [28], Further research across diverse pediatric populations and hospitals is needed.
Causal inferences in quasi-experimental designs require caution due to selection bias and confounding factors. With only 120 participants, the study's statistical power and reliability are limited. Recruitment from a single center questions transferability to other pediatric settings. The narrow age range (8-14 years) excludes younger children who may respond differently to VR. Pain evaluation is subjective, affected by anxiety and past experiences, which can skew results. Self-reported assessments may be inaccurate due to children’s fears and misconceptions. Visibility of VR interventions raises the risk of bias. The novelty effect of VR may distract more than it alleviates pain. Technical issues and environmental factors also influence outcomes, alongside variability in parental behaviors and lack of cost-effectiveness analysis.

Conclusion

This study found that virtual reality (VR) distraction is an effective way to reduce pain during peripheral IV cannulation in children at Allama Iqbal Teaching Hospital, Dera Ghazi Khan. Children who used VR reported significantly lower pain on the Kowai pain scale than those who received standard care. The two groups were comparable in age, gender, and companionship, so the difference in pain is most plausibly attributable to the intervention rather than to demographic factors. The gap was most evident during and immediately after needle insertion, the points at which procedural pain and anxiety typically peak. This suggests that VR works by occupying children's attention and easing both the sensory and emotional burden of the procedure, making it noticeably less distressing.
These findings have clear implications for pediatric nursing practice. VR is a practical, non-pharmacological option that fits into routine care without changing the procedure itself. Because IV cannulation is one of the most common invasive procedures in hospitalized children, adopting VR could meaningfully improve the quality of care and strengthen atraumatic nursing practice. This is especially relevant for public sector hospitals in south Punjab, where low-cost, easily deployed approaches to pain management are most needed. Future research with larger, multi-site samples could confirm these results and guide wider implementation.

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