Implementation of Virtual Reality for Painful Procedures for Pediatric Emergency Care

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Abstract

Problem & Purpose: At an urban Mid-Atlantic teaching hospital, inadequate pain control during procedures was observed to affect a majority of the school-aged patients' pain in the Pediatric Emergency Department (PED). Uncontrolled pain disrupts healthcare delivery within the PED. Of PED nurses surveyed, half felt added stress with unmanaged pain due to multiple attempts at venipuncture or catheter placement without distraction. Virtual Reality (VR) is an evidenced-based tool with established safety and efficacy in pain mitigation for children undergoing painful procedures. This project aims to impact pain during venipuncture through implementation of VR therapy in eligible patients aged 5-17 years old. **Methods**: Approximately 33 patients, 53 PED staff members, and 1 Certified Child Life Specialist (CCLS) were involved in the 12-week initiative. To achieve project goals, CCLS and nursing champions facilitated implementation through staff education. Using a VR algorithm, staff screened and offered VR to eligible patients receiving venipuncture and entered data via a Quick Response (QR) code. Chart audits were conducted to monitor the impact of VR utilization on pain and needle procedure success and ensure inclusion of all eligible children. **Results**: Following implementation, 80% of PED staff were educated on VR. Staff adhered to the VR algorithm 10% of the time. The average VR utilization rate was 25% for eligible patients requiring venipuncture. On a 10-point pain scale, the average pain score was 4.2 for patients where VR was utilized. **Conclusion**: Findings suggest that VR provided distraction practices for patients during venipuncture, indicating improved pain and quality of care in the PED. Barriers impacting implementation included time constraints, high unit acuity, and gaps in documentation. Although VR utilization remains below goal, limited data supports use of VR to improve care within the PED.

Keywords: virtual reality, painful procedures, pediatric emergency, venipuncture, children

Implementation of Virtual Reality for Painful Procedures for Pediatric Emergency Care

In an urban, Mid-Atlantic pediatric emergency department (PED), children routinely experience uncontrolled pain through needle procedures. Pain is defined as the unpleasant sensory and emotional experience influenced by physiological and psychological factors (Correia & Duran, 2017). Inadequate pain control without comfort measures inflicts emotional distress and induces poor coping (Addab, et al., 2022). The combination of pain and anxiety may lead to stressful and traumatizing experiences for children and caregivers in EDs, negatively impacting future care and subsequent procedures throughout the hospital stay (Lluesma-Vidal, et al., 2022). The child in pain also increases the parents' moral distress (Tas, et al., 2022). Allocation of resources to distraction techniques have shown to alleviate pain and fear as well as decrease disruption to workflow (Tas, et al., 2022). Virtual Reality (VR) is a safe and non-pharmacological technique that is highly effective in reducing pain for children undergoing painful procedures (Addab, et al., 2022).

The target pediatric ED is in an urban teaching hospital that serves the special needs of complex populations. Venipuncture is the most common painful procedure at this ED. Uncontrolled pain affected the patient's pain and fear perception, as observed by staff, in a majority of school-aged children from 5-17 years receiving venipuncture at this site. Of PED nurses surveyed, half felt added stress with unmanaged pain due to multiple attempts at venipuncture or intravenous (IV) catheter placement without adequate distraction. Factors such as budget constraints and high unit occupancy contribute to the absence of distraction modalities for procedures as standard practice at the target site. New graduates and travel nurses that lack distraction education and experience comprise 50% of staff that performed venipuncture at this site, leading to distraction underutilization. See Figure 1 for a fishbone diagram illustrating the

root causes of inadequate pain control and psychological distress, which were critical issues affecting healthcare delivery and patient and family satisfaction. The purpose of this quality improvement (QI) project was to impact pain during venipuncture through the implementation of VR therapy in eligible patients aged 5-17 years old in a pediatric ED.

Available Knowledge

Many well-designed randomized controlled trials have demonstrated the safety and efficacy of VR in mitigating pain and fear (Addab, et al., 2022; Tas, et al, 2022). A review of the evidence, presented in Table 1, shows that VR immerses children in a virtual world to minimize current pain sensitivity and has lasting benefits such as decreased needle phobia and procedure-related anxiety into adulthood (Addab, et al., 2022; Chan et al., 2019). Distraction by VR significantly reduces pain and anxiety by displacing the child's attention from a painful procedure to a more pleasurable activity (Addab, et al., 2022). VR was not being utilized in the target ED prior to implementation. According to healthcare professionals, caregivers, and patients, VR had global efficacy in pain and fear reduction and is highly feasible across many clinical settings, including outpatient clinics, inpatient units, and emergency departments (Chan, et al, 2019; Gold et al., 2018; Chen, et al., 2020). VR also facilitates increased patient satisfaction and has potential to prevent caregiver distress and negative health outcomes (Lluesma-Vidal, et al., 2022; Gold et al., 2018; Chen, et al., 2020). Children, their caregivers, and healthcare providers alike report VR as a safe, beneficial, and well-tolerated intervention for routine blood draws and venous access (Gold, et al., 2018; Addab, et al., 2022; Tas, et al., 2022). A synthesis of the findings can be found in Table 2.

Rationale

The conceptual framework of Complex Innovation Implementation was selected to plan the project (Figure 2). This framework highlighted the importance of management support, resource availability, use of policies and procedures, champions of change, and organizational values and climate as contributing to the success of implementation (Helfrich, et al., 2007). VR implementation was expected to be successful since this QI project aligned with both the complex innovation implementation framework and the site's vision to transform healthcare. The target site values excellence and discovery as demonstrated by incorporation of innovative, evidence-based solutions like VR into the clinical environment. The site fostered a culture of openness and empowered staff to translate evidence into practice. This nurturing culture, coupled with strong leadership support and professional collaboration enhanced the patient experience with quality, family-centered care and effective teamwork across all disciplines. Nurses and Child Life Specialists (CCLS) played key roles by championing the use of VR technology and leading practice changes. Through upheld high standards, the organization values education, research, and clinical care, and strived for excellence in these divisions. Cultural highlights include a democratic and inclusive management structure, policies, and support for research and QI as a strong driving force behind the hospital's practice.

Methods

Context

The setting was a 20-bed pediatric ED within a Mid-Atlantic urban teaching hospital with a favorable climate for change and established organizational readiness and structures to implement this project. On the contrary, barriers to VR implementation included time constraints in the fast-paced environment with high unit acuity, inadequate staffing, and lack of standardized practices or guidelines on distraction modalities. Training of new hires did not involve VR, distraction modalities, or psychological distress and fear principles. Nursing culture also

prioritized IV success rates and timeliness of interventions over pain and anxiety, as shown in the Current Process Map outlined in Figure 3. Furthermore, communication with CCLS identified the barrier of limited CCLS coverage in the ED. After informally interviewing key personnel, most nurses relied on caregivers and colleagues for proper, safe positioning and restraint for IV insertions rather than employing distraction techniques due to resource limitations (i.e., CCLS and equipment availability). Nurses reported inadequate education and lack of time in setting up distraction tools due to increased throughput, volume surges, and emergency situations with unstable patients. As a result, procedural pain was insufficiently managed or prioritized.

Intervention

A multidisciplinary VR program that evaluated patient eligibility, pain scores, and VR utilization was obtained through formal commitments from subject matter experts, champions, and stakeholders. This project was guided by a project lead (PL), Clinical Site Representative (CSR), sponsor, and champions, whose roles as project team members were defined in Table 3. Nurses, CCLS, and patient care technicians (PCT) were recruited as project champions, as they work collaboratively to prepare effective distraction strategies tailored to the child's psychosocial, emotional, and developmental needs. Buy-in from the CCLS leadership team and staff was essential to recruit project champions and to incorporate VR as a distraction tool in the ED. Champions promoted and bolstered the use of VR to accomplish the goals of providing comfort to the patient and family. The team screened eligible patients in the ED who required venipuncture and offered VR distraction techniques after assessment, as demonstrated in the Desired Process Map in Figure 4.

KindVR is a company with a mission to engineer VR therapy that mitigates pain and stress for medical procedures. Given that VR programs are typically costly to fund and maintain,

the PL developed a partnership with the KindVR company, who shared the VR resources and technology necessary to implement the program. The project benefited from an opportunity to trial the KindVR product without having to purchase the equipment.

The intervention involved VR distraction via KindVR's head-mounted-display with an interactive game, 3D experience, or video for pediatric patients to choose from when undergoing a venipuncture procedure. A VR eligibility algorithm outlining the intervention, shown in Appendix A, was provided for PED use for children ages 5-17 years old. Exclusion criteria included pediatric patients younger than 5, older than 17, or those with any visual, audio, or cognitive impairments, and unstable medical conditions such as acute respiratory distress that contraindicate VR use. Using a Quick Response (QR) code, staff entered data on VR utilization and pain for all patients who required venipuncture. Educational content was distributed among staff by the identified VR champions. Strategies used to facilitate a successful implementation included staff immersion in dynamic training through weekly VR in-services, collaboration with nursing and CCLS champions, monthly education and reminders to staff, and VR utilization surveys via QR codes. Data reports of key findings and feedback were shared at monthly meetings and incentives were provided for staff who adopted VR to increase engagement.

Measures

The QI project identified structural, process, and outcome goals to measure the success of VR implementation to improve pain, with a focus on venipuncture for pediatric patients aged 5-17 years old. Structure measures needed to facilitate project implementation included incorporation of a VR algorithm into PED practice. Visual cues such as flyers and posters to guide VR were displayed around the unit. Availability of a VR headset device for distraction on the unit was another important structural change needed prior to implementation.

Process measures key to achievement of project aims included staff education, VR adherence, and VR utilization, referenced in detail in the Measurement Plan in Table 4. First, staff education on VR was completed through various in-services and tracked through a REDCap survey shown in Appendix B. Staff education included the use, care, and maintenance of the VR device as well as review of the VR algorithm. Education completion was then fulfilled through accessing a QR code. The percentage of staff educated on VR was tracked to demonstrate knowledge of distraction tools. The takeaway was to promote staff identification of which patients qualified for VR distraction to reduce pain and distress and to prepare patients better psychologically for procedures. Secondly, another process goal was to achieve 100% staff adherence to the VR algorithm to verify appropriateness of screening methods to determine patient eligibility for VR. Measurement of adherence also exhibited staff uptake of the VR algorithm. Lastly, VR utilization reflected the percentage of patients receiving VR over those eligible for the intervention, and was measured using a REDCap survey shown in Appendix C. To ensure all eligible participants were included and offered VR, the PL conducted chart audits and used weekly reports generated by information technology (IT) on all IVs and blood draws performed within the PED.

The outcome measure of VR's impact on pain can be accomplished through use of a validated visual and numerical pain scale. As shown in Figure 5, pain was measured from 0 - 10 using the Wong-Baker^{TM} Visual Analog Scale (VAS)[1], which quantified the degree of pain based on self-report through an established tool with high validity and reliability (Bielsky, 2010). Both healthcare providers and caregivers relied on the objective psychometric qualities of the VAS to measure pain in children. To reflect the impact of VR implementation on pain, staff assessed and

captured patient-reported pain from venipuncture via a QR code. The outcome goal was an average pain score < 5 for patients utilizing VR distraction during venipuncture.

Data collection occurred over 12 weeks from November 2023 to January 2024. Staff education and VR utilization data was entered and recorded via the HIPAA-compliant, secure, and password-protected REDCap system in accordance with institutional policies. Chart audits and IT data reports during this period helped the PL assess VR algorithm adherence with appropriate VR implementation. Leadership and culture at the site helped facilitate the QI initiative. Unfortunately, high turnover, staff time constraints, and the high acuity and emergency nature of the ED pose as barriers to project success. The PL performed weekly oversight of the project, in collaboration with a CSR and CCLS, to provide strong support and feedback related to the VR initiative in monthly meetings.

Ethics

This QI project was determined to be non-human subjects' research, by the Human Research Protections Office (HRPO) of the University of Maryland Baltimore's Institutional Review Board (IRB). Information collected and entered into REDCap was encrypted to protect health information and to maximize patient safety and data security. To protect patient confidentiality and privacy, identifiers were coded by REDCap and only accessible to the PL and project faculty through a virtual private network. There were no conflicts of interest, and no affiliation with, nor any financial compensation, from the KindVR company or pediatric ED.

Results

Prior to implementation, the goals of VR algorithm integration and availability of VR equipment were successfully achieved on the unit with the necessary structures in place. These readily accessible VR resources were fundamental for implementation at the site.

Data on education, VR utilization, and pain were collected electronically and trended weekly to show improvement over the 12 weeks of VR implementation in the PED. Following implementation, 80% of PED staff were educated on VR distraction (Figure 6). Staff consisted of physicians, nurses, PCTs, and one CCLS. The average VR utilization rate was 25% for eligible patients requiring venipuncture. VR utilization data was analyzed through a run chart (Figure 7) where inferences were drawn over time to determine the success and use of the VR initiative for documented eligible patients. At two points throughout the timeline, there were shifts noted in the run chart over 2 to 3 weeks in the beginning and middle of the project, suggesting initial effective education through hands-on training by project champions and weekly PL presence. An increase in VR utilization to 100% occurred during weeks 3 and 7. However, there was a drop noted from weeks 8 through 11 associated with a pattern of non-adherence to the algorithm. Overall, there was a 10% adherence to the algorithm, which influenced lower VR utilization. To address adherence and utilization rates below goal, the PL and CSR presented education reminders at a monthly all-staff meeting during week 6 and provided another in-service at week 11. VR adherence and utilization, as a result, slightly increased following these strategies but no consistent trends or shifts were observed. Data reports obtained halfway through the project, from weeks 7 to 12, and weekly chart audits helped determine the total number of patients eligible to be 33, but lack of data entry and missing data subsequently hindered interpretation.

Of patients receiving venipuncture, 68% were ineligible for VR due to contraindications based on chart audits and IT reports. However, out of those eligible, a mean percentage of 30% were offered VR, as shown in Figure 8. It is noteworthy to highlight that patients chose VR when offered for distraction 50% of the time, an unexpected finding that emphasized the importance of providing resources for distraction.

The project used a validated pain scale to measure the outcome. On a 10-point pain scale, the average pain score was 4.2 for patients where VR was utilized. Pain scores and percentages of VR utilization were monitored on a weekly basis to help interpret the benefits of VR for children undergoing venipuncture. Findings suggested that patients utilizing VR for venipuncture demonstrated an average pain score < 5, in alignment with the outcome goal. Additionally, through conversations with staff and team members that monitored the project, it was found that many positive patient and family experiences were reported and observed with VR.

Discussion

The KindVR equipment was always available on the unit, and this ease of access allowed for increased use on eligible patients. However, the single device is subject to battery depletion if not regularly charged and requires sanitation to reduce infection risk. A common reason cited for not using VR was low battery. These concepts were reinforced during staff education on VR and at monthly meetings. Sustainability plans involve applying for grants to fund VR and continued investment in services and initiatives that improve satisfaction and the quality of care patients receive to offset the cost of equipment, which ranges from $200 to $5,000 depending on the device or program. Financial barriers to implementation were effectively addressed through a free trial of the KindVR bundle consisting of one VR headset device, remote troubleshooting/IT support, product warranty, software updates, and charging equipment. Potential costs associated with inadequate distraction includes medical care due to pain, unsuccessful IV attempts and delays in care, and disruption in patient flow and provider workload which may cumulatively exceed the cost of project implementation (Tas, et al., 2022).

Project champions facilitated the success of the implementation by educating and supervising staff on VR for distraction during procedures. With CCLS available as non-nursing

staff, nurses were able to focus on care delivery and completion of procedures with CCLS advocating for distraction techniques and performing a psychosocial assessment of the patient's needs. CCLS involvement with real-time device advocacy and support decreased the burden on nursing staff and increased algorithm adherence. This multidisciplinary collaboration influenced staff members who were resistant to change. Furthermore, to achieve staff buy-in and increase VR usage, the PL incentivized clinicians who adopted VR with a prize raffle to award and motivate staff.

This QI project provides initial support regarding the feasibility of implementing VR for pain during venipuncture in a pediatric ED. Literature findings support the implementation of VR to improve procedural pain and decrease discomfort felt by children undergoing such procedures (Addab, et al., 2022). Similar to the evidence-based studies using VR, this project also noted the collaboration between nursing and CCLS as a facilitator for improved pain and fear outcomes (Addab, et al., 2022; Chan, et al, 2019; Tas, et al, 2022). According to the literature, VR was successfully implemented across a variety of healthcare settings for pain and fear mitigation, notably in emergency departments (Gold et al., 2018; Chen, et al., 2020). Another key insight that mimicked literature results were the positive patient and family experiences with VR obtained through interviewing project team members, staff, and patients. Despite the established efficacy of VR in literature to improve pain and distraction in the PED, the same results were not completely translated in part due to high acuity and volume surges during a busy respiratory season as evidenced by the small sample size captured. As a result of the viral outbreaks occurring throughout the fall and winter seasons, the site did not have significantly favorable outcomes nor was implemented at an opportune time.

The VR algorithm was adhered to 10% of the time, indicating a need for continued education and reminders. Barriers to VR implementation include time constraints in a fast-paced environment with high unit acuity, inadequate staffing, contraindications for VR use, and gaps in documentation. Variations in the run chart data revealed the difficulties in implementing VR during a pandemic, with many barriers influencing practice change.

Implementation occurred during a busy respiratory season, in which a majority of patients were presenting with acute respiratory distress, which disqualified them from VR. Staff cited a main barrier to adherence was due to confounding variables of patient volume surges and high acuity. Another factor contributing to the lower VR utilization rates involved lower age ranges, as most patients during this period were noted to be under the age of 5 years old, thus ineligible. The site saw many complex and special patient populations presenting in acute conditions in the fall and winter that were not eligible for VR, which was a main point of limitation compared to the literature. Patterns of non-adherence were noted during weeks 4 to 5 and 8 through 11. Chart audits and IT reports determined that this was due to patients meeting high acuity or exclusion criteria. Adherence and utilization rates were subpar which prompted meetings with the project team and rolling refreshers to staff.

There were discrepancies in the number of actual patients eligible for VR, as suggested by the data points in the run chart where VR was not used or offered. Large gaps in eligibility appears to be related to non-adherence to documentation because staff only documented data if they offered or used VR, otherwise no conclusive data was captured on whether patients were eligible. Chart review and IT reports indicated that more patients were eligible, but this was not adequately captured in the project documentation tool. This gap led to limitations in data interpretation and understanding of VR's impact at the project site.

Since staff education rates did not achieve a goal of 100%, the inadequacy in education may explain why VR utilization rates also remained low. The inconsistency in staffing impacted education rates and ability to reach those who worked less than full-time, only receiving monthly reminders. CCLS experienced similar issues with staff coverage. There were challenges in hiring and training new staff, which typically takes weeks to months.

Conclusion

Overall, although VR utilization remains below goal, limited data supports the use of VR to improve care within the PED. The project aimed to optimize the comfort of the patient with an evidenced-based tool with established safety and efficacy in pain mitigation for children undergoing painful procedures. Findings from this project suggest that VR provided distraction practices for patients during venipuncture, indicating improved pain and quality of care in the PED. Strengths of this project included staff enthusiasm and positive patient and family experiences. Limitations involve a high acuity, fast-paced environment with time constraints, inadequate staffing, patient contraindications, small sample size, and non-adherence to documentation, leading to limited interpretation of results. Implementation showed that with increased standardization and knowledge of VR distraction, staff can impact procedural pain in the PED.

For sustainability, further implementation and support through re-education and integration into new staff orientation is necessary to increase engagement and adherence to the algorithm. Further refining data reports to facilitate data collection is recommended. Funding is required to support VR initiatives long-term to demonstrate the effectiveness of VR therapy and to enhance the comfort of the patient and broaden staff knowledge of distraction techniques.

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Table 1

Evidence Review Table

Citation: Addab, S., Hamdy, R., Thorstad, K., Le May, S., & Tsimicalis, A. (2022). Use of virtual reality in managing paediatric procedural pain and anxiety: An integrative literature review. *Journal of Clinical Nursing, 31*(21/22), 3032–3059. doi:10.1111/jocn.16217	**Level and Quality II-A**
Purpose or Hypothesis	The purpose of this research study was to determine if virtual reality is a superior distraction tool in the healthcare settings, within the context of helping patients manage pain and anxiety with burn wound care and other medical procedures.
Type of Evidence Research Design	Systematic Review and Meta-Analysis conducted using PRISMA across four databases
Sample Population, Size, Setting	**Sampling Technique:** Systematic. **Eligible Participants:** Patients aged 18 years and below undergoing a medical procedure with VR distraction. **Setting:** Multiple children's healthcare settings, mainly hospitals **Excluded:** Studies that only included adults (age over 18), did not use VR as a distraction tool, did not use VR during a medical procedure, did not measure pain or anxiety **Accepted:** A total of 77 studies were included for review between 2000 and 2021 with 2,174 patients aged 6 months to 18 years receiving the VR intervention during one of the following medical procedures: burn wound care, post-burn physiotherapy, dental, needle-related and other procedures. Additionally, ten studies included samples with adults, since pediatric data could not be separated (n = 507). **Control:** Most studies had a within-subject design, where participants experienced both VR and the control condition (standard distraction or standard of care). **Intervention:** 507 participants **Power analysis/Achieved:** Not discussed/calculated – large overall sample size of 2,174 patients across 77 studies varying in sample size **Group Homogeneity**: Not discussed/tested – sampled only children undergoing medical procedures with variation in diagnoses across many settings
Intervention Procedures	**Control Protocol:** Standard of Care (SOC) or alternate form of distraction (television, vibration, cards, etc.) **Intervention Protocol:** Virtual Reality distraction – head-mounted-display (HMD) with an interactive game, 3D experience, or video **Treatment Fidelity:** No treatment fidelity discussed, no mention of training of observers/healthcare providers/nurses
Primary Outcome and Measures	**Dependent Variable:** Procedural pain or anxiety **DV Measure:** APPT-WGRS, Adolescent Pediatric Pain Tool; FLACC, Face, Legs, Activity, Cry, Consolability scale; FPS, Faces Pain Scale; GRS, Graphic Rating Scale; NRS, Numerical Rating Scale; SSAIC, Spielberger State-Anxiety Inventory for Children; STAI-CH, State-Trait Anxiety Inventory for Children; VAS, Visual Analogue Scale; VAT, Visual Analogue Thermometer

Results/Conclusions	**Statistical Results:** 11-18 studies found that VR distraction, compared to SOC statistically significantly reduced needle-related procedural pain and anxiety. Majority of studies reported significant pain reduction with VR. 10 studies found no significant difference in pain for VR distraction when compared to other forms of active and passive distraction, or pharmacological interventions. **Conclusions**: Overall, the evidence from the studies supports the use of VR in managing procedural pain and anxiety in the pediatric population. VR immerses children in a virtual world to reduce pain and fear with medical interventions and prevent increased pain sensitivity and procedure-related anxiety into adulthood. Nurses play key roles by championing the use of VR technology and leading practice changes with EBP.

Citation: Tas, F. Q., van Eijk, C. A. M., Staals, L. M., Legerstee, J. S., & Dierckx, B. (2022). Virtual reality in pediatrics, effects on pain and anxiety: A systematic review and meta-analysis update. *Paediatric Anaesthesia*. https://doi.org/10.1111/pan.145	**Level and Quality I-A**
Purpose or Hypothesis	The purpose of this research study explores the effectiveness of virtual reality (VR) as a distraction technique and exposure tool to reduce pediatric pain and anxiety in pediatric patients undergoing medical procedures.
Type of Evidence Research Design	Systematic Review and Meta-Analysis of RCTs
Sample Population, Size, Setting	**Sampling Technique:** Systematic. **Eligible Participants:** Patients under 21 years of age undergoing medical procedures. **Setting:** Children's healthcare settings **Excluded:** Non-RCTs, non-somatic patients, adults aged older than 21 years, studies with low methodological quality using sensitivity analysis. **Accepted:** The search yielded 1824 studies, of which 13 met the inclusion criteria (mean/median score for pain or anxiety during the procedure and measure of dispersion), added to the 13 articles from an extension of Eijlers et al.'s systematic review, resulting in 26 total studies extending to 2020. **Intervention:** VR was the intervention (n = 23) during medical procedures or as exposure (n = 4) before medical procedures. **Power analysis/Achieved:** SMD of 0.67 represents a medium effect size – Power Analysis met **Group Homogeneity**: Intervention/Control homogeneous/similar at baseline, but there was heterogeneity in VR interventions as well as response in young children versus older children. Heterogeneity was mostly between 60% and 70%, which can be seen as substantial heterogeneity.
Intervention Procedures	**Control Protocol:** Care as Usual (CAU) **Intervention Protocol:** Virtual Reality distraction – head-mounted-display (HMD) **Treatment Fidelity:** No treatment fidelity discussed, no mention of training of observers/healthcare professionals/caregivers
Primary Outcome and Measures	**Dependent Variable:** Pain and anxiety scores **DV Measure:** Mean scores and SDs for pain and anxiety during the procedure measured in the VR intervention and standard care groups or estimated using median scores and interquartile ranges. Self-reported pain and anxiety were primary outcomes or using validated visual scales or questionnaires (FLACC, face, legs, activity, cry, consolability; FPS-r, faces pain scale-revised; VAS). Additionally, the review included caregivers and/or professionals' reports on perceived pain/anxiety of the child as secondary outcomes.

Results/Conclusions	**Statistical Results:** The effect size of VR distraction on pediatric self-reported pain during a medical procedure was statistically significant (SMD = −0.67; 95% CI, −0.89 to −0.446; $p < .001$) as well as patient-reported anxiety (SMD = −0.74; 95% CI, −1.00 to −0.48; $p < .001$). **Conclusions**: Medical procedures are associated with pain and anxiety in pediatric patients. Patient-reported pain was significantly reduced when measuring standardized mean scores (based on 21 studies) as well as patient-reported anxiety (based on 10 studies). Research on VR is evolving for various applications in clinical settings. VR was primarily studied in patients receiving venous access (n = 10). Anxiety levels varied in effect size when reported by professionals (larger effect size) versus by parents (smaller effect size) than patient-reported anxiety.

Citation: Chan, E., Hovenden, M., Ramage, E., Ling, N., Pham, J. H., Rahim, A., ... & Leong, P. (2019). Virtual reality for pediatric needle procedural pain: Two randomized clinical trials. *The Journal of Pediatrics*, *209*(160-167). https://doi.org/10.1016/j.jpeds.2019.02.034	**Level and Quality I-A**
Purpose or Hypothesis	The purpose of this research study aimed to assess the efficacy and safety of VR distraction for needle pain at two hospital settings: the emergency department (ED) and outpatient pathology.
Type of Evidence Research Design	Two concurrent, randomized controlled trials
Sample Population, Size, Setting	**Sampling Technique:** Simple Random. **Eligible Participants:** Children ages 4-11 years undergoing venous needle procedures **Setting:** Two tertiary pediatric hospitals in Australia – the emergency department (ED) and outpatient pathology **Excluded:** Critical medical illnesses or deteriorating clinical status, medical conditions that precluded VR use or study instrument completion, and the inability to consent/assent **Accepted:** 254 patients from ED or pathology settings, randomized to either VR or SOC **Control:** In the ED, 59 children had SOC. In pathology, 68 children assigned to SOC, with 2 children withdrawing assent (n = 66). **Intervention:** In the ED, 64 children were assigned to VR. In pathology, 63 children were assigned to VR. **Power analysis/Achieved:** 114 subjects required to meet 80% Beta, .05 Alpha – Power Analysis met (n =123 and 131) **Group Homogeneity**: Heterogenous
Intervention Procedures	**Control Protocol:** Standard of Care (SOC) **Intervention Protocol:** Virtual Reality distraction – head-mounted-display (HMD) **Treatment Fidelity:** Two authors developed a virtual reality sequence based on their clinical practice, with iterative input from child life therapy, medical, pathology, and nursing staff.
Primary Outcome and Measures	**Dependent Variable:** Change in baseline pain main outcome; secondary DVs included change in child-rated anxiety, caregiver's rating of their child's distress, the need for restraint, number of needle attempts and success, the child's withdrawal of their arm, and the need for procedural sedation. **DV Measure:** Baseline pain was measured between the VR and SOC groups based on patient-rated Faces Pain Scale-Revised (FPS-R) or visual analogue scale, 0-10.

Results/Conclusions	**Statistical Results:** From baseline, children assigned to SOC had no change in FPS-R (0.39; 95% CI, −0.67 to 1.45; P = .47). However, the virtual reality group had a significant reduction in pain (−1.39; 95% CI, −2.42 to −0.36; P = .009). **Conclusions**: In the ED, there was no change in baseline pain with SOC, whereas VR showed a significant reduction in pain. In pathology, both groups experienced an increase in pain from baseline, but pain was significantly less in the VR group than SOC group. Among both studies, 10 participants experienced minor adverse events, equally distributed between VR/SOC but none required pharmacotherapy. All in all, for pediatric patients undergoing intravenous cannulation or venipuncture, VR was safe and successful in decreasing pain.

Citation: Lluesma-Vidal, M., Carcelén González, R., García-Garcés, L., Sánchez-López, M. I., Peyro, L., & Ruiz-Zaldibar, C. (2022). Effect of virtual reality on pediatric pain and fear during procedures involving needles: Systematic review and meta-analysis. *JMIR Serious Games, 10*(3), e35008. https://doi.org/10.2196/35008		**Level and Quality II-B**
Purpose or Hypothesis	The purpose of this research study aimed to analyze current evidence for the efficacy of VR as a distraction tool for children from pain and fear during needle procedures as compared to that of standard techniques.	
Type of Evidence Research Design	Systematic review and meta-analysis with randomized clinical trials (RCTs) or quasi-RCTs	
Sample Population, Size, Setting	**Sampling Technique:** Systematic. **Eligible Participants:** Participants aged 21 years and under who underwent needle procedures (venipuncture) **Setting:** Hospitals or primary care settings in North America **Excluded:** Adult population (over 21 years), did not use VR, non-RCT design, main outcome measure was not pain, non-needle procedures **Accepted:** The search yielded 665 results, and included 21 studies, most of which reported low methodological quality. The cohorts sampled ranged from 15 to 220 participants. Ten studies were included in the meta-analysis. **Control:** Varied by study, not all studies had a control group **Intervention:** Ranged from 15 to 220 participants **Power analysis/Achieved:** 10 out of the 21 studies achieved large effect size, others did not discuss – Power Analysis met **Group Homogeneity**: Neither study or participants were homogeneous in terms of age or characteristics, medical procedures analyzed, or tools used to measure pain.	
Intervention Procedures	**Control Protocol:** Not discussed/studied **Intervention Protocol:** VR technique for distraction **Treatment Fidelity:** No treatment fidelity discussed, no mention of training of observers/healthcare professionals/caregivers	
Primary Outcome and Measures	**Dependent Variable:** Pain **DV Measure:** Pain measured using the Wong-Baker Faces Pain Rating Scale (WBFPS) or visual analog scale (VAS), validated instruments.	

Results/Conclusions	**Statistical Results:** The global effect of using VR as a distraction measure had significantly reduced pain in children in the experimental groups (IV –2.37, 95% CI –3.20 to –1.54; Z=5.58; P<.001) and fear (IV –1.26, 95% CI –1.89 to –0.63; Z=3.92; P<.001). **Conclusions**: VR as a distraction measure had a global effect of significant reduction in pain and fear in children during procedures involving needles. Virtual reality (VR) can be used as distraction for painful clinical procedures associated with needles, including vaccinations, blood draws, or medication administration, which cause increased levels of pain and fear in children.

Citation: Gold, J. I., & Mahrer, N. E. (2018). Is virtual reality ready for prime time in the medical space? A randomized control trial of pediatric virtual reality for acute procedural pain management. *Journal of Pediatric Psychology*, *43*(3), 266–275. https://doi.org/10.1093/jpepsy/jsx129		**Level and Quality I-A**
Purpose or Hypothesis	The purpose of this research study aimed to assess the feasibility and efficacy of virtual reality (VR) compared with standard of care (SOC) for reducing pain, anxiety, and improving satisfaction associated with blood draw in children.	
Type of Evidence Research Design	Randomized controlled trial	
Sample Population, Size, Setting	**Sampling Technique:** Convenience. **Eligible Participants:** Children ages 10–21 years undergoing a routine a blood draw. **Setting:** Outpatient pathology lab at an urban pediatric hospital in Los Angeles **Excluded:** Patients with a cognitive disability or developmental delay, history of seizure, current pain or anxiety medication, flu-like symptoms, or a visual or auditory impairment that would interfere with ability to use VR according to patient and caregiver report **Accepted:** 143 triads consisting of the patient, their caregiver, and phlebotomist, and randomized to either VR or SOC intervention groups **Control:** 77 patients received SOC, 4 excluded from analysis d/t not completing post-measures or blood draw **Intervention:** 72 patients received VR, 2 excluded from analysis d/t wanting to watch procedure or VR game not loading **Power analysis/Achieved:** 100 subjects required to meet 80% Beta for moderate effect size – Power Analysis met (n = 146) **Group Homogeneity**: No significant group differences in age, grade, gender, number of previous blood draws, or ethnicity (all p-values >0.12)	
Intervention Procedures	**Control Protocol:** Standard of Care (SOC) **Intervention Protocol:** Standard of Care (SOC) plus Virtual Reality (VR) game **Treatment Fidelity:** Study personnel approached patients and their families in the phlebotomy waiting room to determine interest and eligibility, were not blinded in post-procedure measures; no discussion/mention of training	
Primary Outcome and Measures	**Dependent Variable:** Procedural pain and anxiety, affect, and satisfaction **DV Measure:** Patients and caregivers completed a Visual Analogue Scale (VAS) and Colored Analogue Scale (CAS) ranging from 0 indicating “no pain” to 10 indicating “worst pain” to report on pain intensity pre- and post-procedure. Both also completed the Faces Pain Scale-Revised to measure affective pain (worry and bother related to pain) pre- and post-procedure. Anxiety was measured by patients and caregivers pre- and post-procedure using the VAS for anxiety and the Facial Affective Scale (FAS). Researchers developed the Child Presence Measure to assess the degree of immersion and satisfaction in the game using a Likert scale for 12-item measures.	

Results/Conclusions	**Statistical Results:** Bivariate correlations revealed that gender was significantly related to procedural pain; r = -0.22, p < .05 and r = -0.25, p < .01), anxiety (r = -.18, p < .05), affect (r =-.24, p < .01), and age (r = -.20, p < .05; r = -.17, p < .05, r = -.21, p < .05). Anxiety sensitivity significantly related to higher procedural anxiety (r = -.20, p < .05). Patients reported high levels of immersion and satisfaction with the VR game (M (SD) = 22.75 (6.32). 92% of patients in the VR condition reported no simulator sickness. **Conclusions**: The RCT found that VR significantly reduced acute procedural pain and anxiety compared with SOC. Findings showed that children with baseline high anxiety sensitivity undergoing routine blood draw benefitted more from VR. Patients and caregivers in the VR group reported high levels of satisfaction with the procedure. According to patients, caregivers, and phlebotomists, VR is a feasible, tolerated, and well-liked experience for routine blood draw. VR also facilitates increased satisfaction and has potential to prevent caregiver distress and negative health outcomes.

Citation: Piskorz, J., & Czub, M. (2018). Effectiveness of a virtual reality intervention to minimize pediatric stress and pain intensity during venipuncture. *Journal for Specialists in Pediatric Nursing*, *23*(1), e12201.	**Level and Quality II-B**
Purpose or Hypothesis	The purpose of this research study is to assess the usability and effectiveness of novel hands-free VR device in the treatment of acute procedural pain.
Type of Evidence Research Design	Quasi-experimental Study, post-test only
Sample Population, Size, Setting	**Sampling Technique:** Convenience. **Eligible Participants:** Patients aged 7 – 17 years receiving venipuncture procedure **Setting:** Pediatric Nephrology Clinic **Excluded:** Patients that did not verbally consent to VR **Accepted:** Recruited 38 patients (age range 7–17 years) in a posttest group **Control:** 19 patients **Intervention:** 19 patients **Power analysis/Achieved:** Cohen's *d* was 0.863, which reflected a large effect size – Power Analysis met **Group Homogeneity**: Not discussed/tested – sampled only children undergoing blood draws within a single nephrology clinic (similar diagnoses)
Intervention Procedures	**Control Protocol:** No VR **Intervention Protocol:** VR distraction wearing a head-mounted Oculus DK2 HMD, and playing a game based on Multiple Object Tracking (MOT) task, designed by authors of the study. The game had players memorize and simultaneously track moving targets. **Treatment Fidelity:** Authors of the study designed and implemented the VR MOT game; MOT was evidenced to help with attention and working memory. The hands-free game was designed for application to all age ranges of participants in the study. Training on VR for children conducted on the same day of recruitment. Research assistants aided in data collection.

Primary Outcome and Measures	**Dependent Variable:** Pain and stress levels **DV Measure:** Patients rated their pain and stress intensity on visual analogue scales (VAS) on a scale of 0 to 100 and completed a short questionnaire post-procedure. The VAS scale has high reliability as an acute pain measurement tool.
Results/Conclusions	**Statistical Results:** The VR group reported significantly lower pain intensity than the controls (mean = 15.16 ± 20.51 vs. 37.05 ± 30.66; t = 2.59, df = 36, p < .02, d = 0.863), with similar results for stress level (11.16 ±18.58 vs 41.89 ± 40.89; t = 2.98, df = 36, p < .01, d = 0.993). **Conclusions**: The VR group reported significantly lower pain and stress than the controls, no correlations with age. VR is effective in minimizing pediatric pain and stress due to venipuncture. The MOT-based VR game was appropriate for children in the studied age range.

Citation: Chen, Y., Cheng, S., Lee, P., Lai, C., Hou, I., & Chen, C. (2020). Distraction using virtual reality for children during intravenous injections in an emergency department: A randomised trial. *Journal of Clinical Nursing, 29*(3–4), 503–510. https://doi.org/10.1111/jocn.15088	**Level and Quality I-A**
Purpose or Hypothesis	The purpose of this research study was to determine if VR as a distracting intervention could reduce pain and fear in school-aged children receiving intravenous (IV) injections at an emergency department.
Type of Evidence Research Design	Randomized controlled trial conducted in accordance with CONSORT guidelines
Sample Population, Size, Setting	**Sampling Technique:** Convenience. **Eligible Participants:** Children aged 7–12 years undergoing IV procedure **Setting:** Emergency department (ED) of regional teaching hospital in Taiwan **Excluded:** Children with developmental delay, epilepsy, or heart diseases; undergoing chemotherapy; visually or hearing impaired; nearsighted with more than 8.0 diopters or farsighted with 5.0 diopters; sustained head trauma in the past month; obese according to BMIs; required blood transfusions and blood preparation to be performed; and those who received two or more intravenous injections and had their blood drawn only one time. **Accepted:** 136 children and their primary caregivers who could communicate in Mandarin or Taiwanese. **Control:** 68 patients **Intervention:** 68 patients in experimental group **Power analysis/Achieved:** 135 subjects required to meet 80% Beta, .05 Alpha, and moderate effect size – Power Analysis met **Group Homogeneity**: Intervention/Control homogeneous based on NS p values on Table 1 for demographics and clinical characteristics
Intervention Procedures	**Control Protocol:** Routine IV procedure without VR **Intervention Protocol:** Immersive VR experience during IV procedure **Treatment Fidelity:** Master's prepared research student enrolled participants who met criteria and obtained consent and facilitated the intervention; nurses who were performing IVs were not trained in VR

Primary Outcome and Measures	**Dependent Variable:** Pain and fear **DV Measure:** Children rated their pain and fear along with their caregivers and primary nurses (observation) using the Wong–Baker FACES Pain Rating Scale and Children's Fear Scale. The time required for successful IV insertion was also recorded.
Results/Conclusions	**Statistical Results:** The average times spent for intravenous injections in the experimental group were shorter than the control group, confirming that use of VR significantly reduced the time required to successfully complete intravenous injections ($p = .046$). Pain and fear scores were significantly lower in the VR group for the children ($p = .031$; $.043$), their caregivers ($p = .020$; $.003$) and nurses ($p = .012$; $.006$). **Conclusions**: Pain and fear scores were significantly lower in the VR group, as were perceived by their caregivers and nurses. In addition, children's ratings of pain and fear were positively correlated with the caregivers' and nurses' ratings. The time required for successful IV insertion was also significantly lower in the VR group. VR is useful for the school-aged group during IV placement.

Table 2

Evidence Synthesis

JHNEBP Model Level	Total Number of Sources	Author and Quality Rating of each study	Synthesis of Findings
Level 1 Experimental study · Randomized Controlled Trial (RCT) · Systematic review of RCTs with or without meta-analysis	3 RCTs and 1 systematic review of RCTs with meta-analysis	Chan et al. 2019 (A) & Tas et al. 2022 (A) & Gold et al. 2018 (A) & Chen et al. 2020 (A)	Chan et al. (2019) and Tas et al. (2022) found that VR may significantly mitigate pain and anxiety in children undergoing medical procedures. Both studied various medical procedures but concluded significant results on needle-related procedures. Both studies acknowledged the clinical efficacy and feasibility of VR as distraction and pain reduction tool. Gold et al. (2018) explored patient satisfaction with VR and simulator sickness symptoms (nausea and vomiting) in addition to pain and anxiety. Gold et al. (2018) and Chen et al. (2020)'s studies evaluated the complex factors that contribute to perceived pain and anxiety from multiple perspectives including patients, caregivers, and phlebotomists/nurses in pre- and post-procedure measures. Chen et al. (2020) found that VR can significantly reduce the time spent for successful intravenous insertions.
Level II Quasi-experimental studies · Systematic review of a combination of RCTs and quasi-experimental studies, or quasi-experimental studies only, with or without meta-analysis	2 Systematic reviews of RCTs, quasi-experimental, and mixed methods RCT studies and 1 quasi-experimental study	Addab et al., 2022 (A) & Lluesma-Vidal et al. 2022 (B) & Piskorz & Czub 2018 (B)	Addab et al. (2022) and Lluesma-Vidal (2022) found that VR had beneficial effects of reducing pain and anxiety in children undergoing medical procedures. Both recommended VR for managing pediatric pain and anxiety in clinical settings. Cybersickness was another factor to consider. Both Piskorz & Czub (2018) and Addab et al. (2022)'s studies link the importance of the results to nursing practice, as venipuncture is directly related to the work of nurses, who are advocators for patients and can lead practice changes with evidence that VR effectively distracts and reduces pain and fear during venipuncture.
Level III	-	-	
Level IV	-	-	
Level V	-	-	

Table 3

Site Team Table

Team Member Role	Responsibilities
1. Project Leader	• Gather support and resources for project implementation • Recruit superusers • Manage project: develop project plan and timeline, set goals • Oversee data collection (survey distribution) and chart auditing • Disseminating evidence for best practice • Arrange meetings with stakeholders and VR companies for product trials • Allocating funding and applying to grants to source VR program • Guide staff education rollout/in-services
2. Clinical Site Representative	• Provide feedback and advising on project plan • Assist with implementation and conflict resolution • Assist with algorithm integration and distribution • Liaison between stakeholders (management and staff and VR company) • Provide constructive feedback and solutions throughout project planning • Evaluation of QI project and chart auditing for data collection
3. Sponsor	• Approve project for institution • Provide feedback and insight on DNP project • Assist with obtaining IRB approval and project planning within organization
4. Informatics Coordinator	• Resource for electronic health record (EHR) / IT solutions • Offer ideas throughout project planning • Assist with data collection • Engage IT support as needed
5. Senior Nurses	• Offer ideas throughout project planning • Incorporate VR education into staff and patient education • Assist with superuser recruitment • Nurse Advocate/superuser of VR
6. VR Champions (Nurses and Child Life)	• VR superuser and facilitator • Facilitate unit implementation of VR and screening patients for project • Collection of survey responses/data • Meetings with team to recommend VR solutions/games/feedback

7. Project Faculty Advisor	• Point of contact for School of Nursing • Reviews DNP Project Proposals and offers feedback on project details/planning • Meetings to discuss project logistics

Table 4

Measurement Plan from Project Charter

Measurement Plan		
Project Goals	Data Collection Procedures (who, how, when)	Name of Data Collection Tool
One VR headset device will be available for distraction on the unit by November 2023	**Who:** Project Lead and Champions **How:** Stored and charged on unit **When:** November – January	KindVR device
A VR algorithm will be created for the PED by December 2023	**Who:** Project Lead, CSR, and Champions **How:** Visual cues/posters **When:** November – January	VR Algorithm
100% of PED staff with complete VR training with demonstrated knowledge of distraction tools and pain education by December 2023	**Who:** Project Lead and Champions **How:** Data reports from staff checked off on training **When:** November – December	Staff Education on VR
100% of eligible patients requiring venipuncture will be offered VR distraction techniques by January 2024	**Who:** Project Lead, CCLS, VR Champions **How:** Chart audits and Surveys **When:** Weekly	VR Eligibility
100% of patients utilizing VR distraction for venipuncture will demonstrate perceived pain score < 5 by January 2024	**Who:** Project Lead and CSR **How:** Data reports from chart audits and surveys **When:** Weekly	VR Utilization

Figure 1

Fishbone Diagram

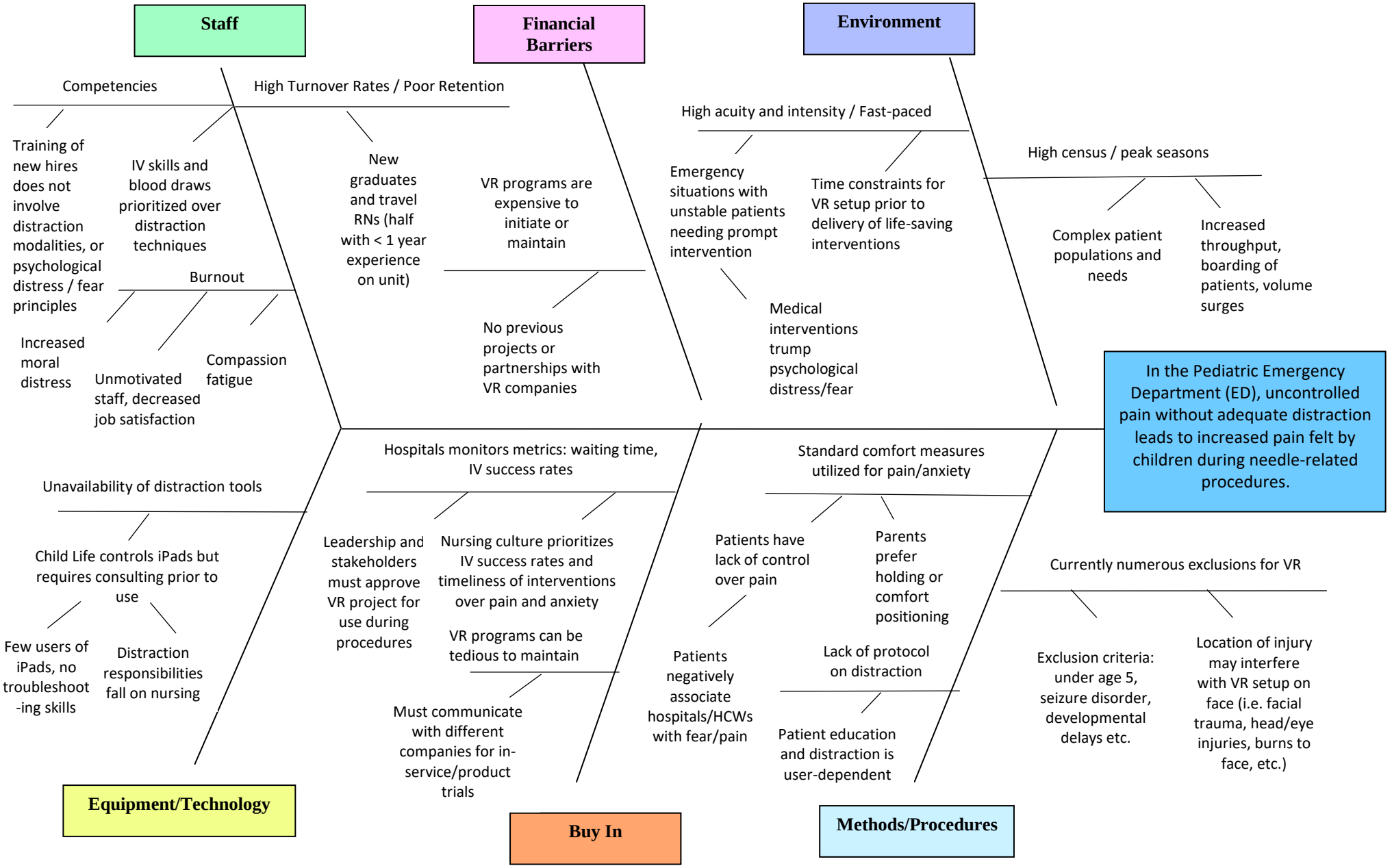
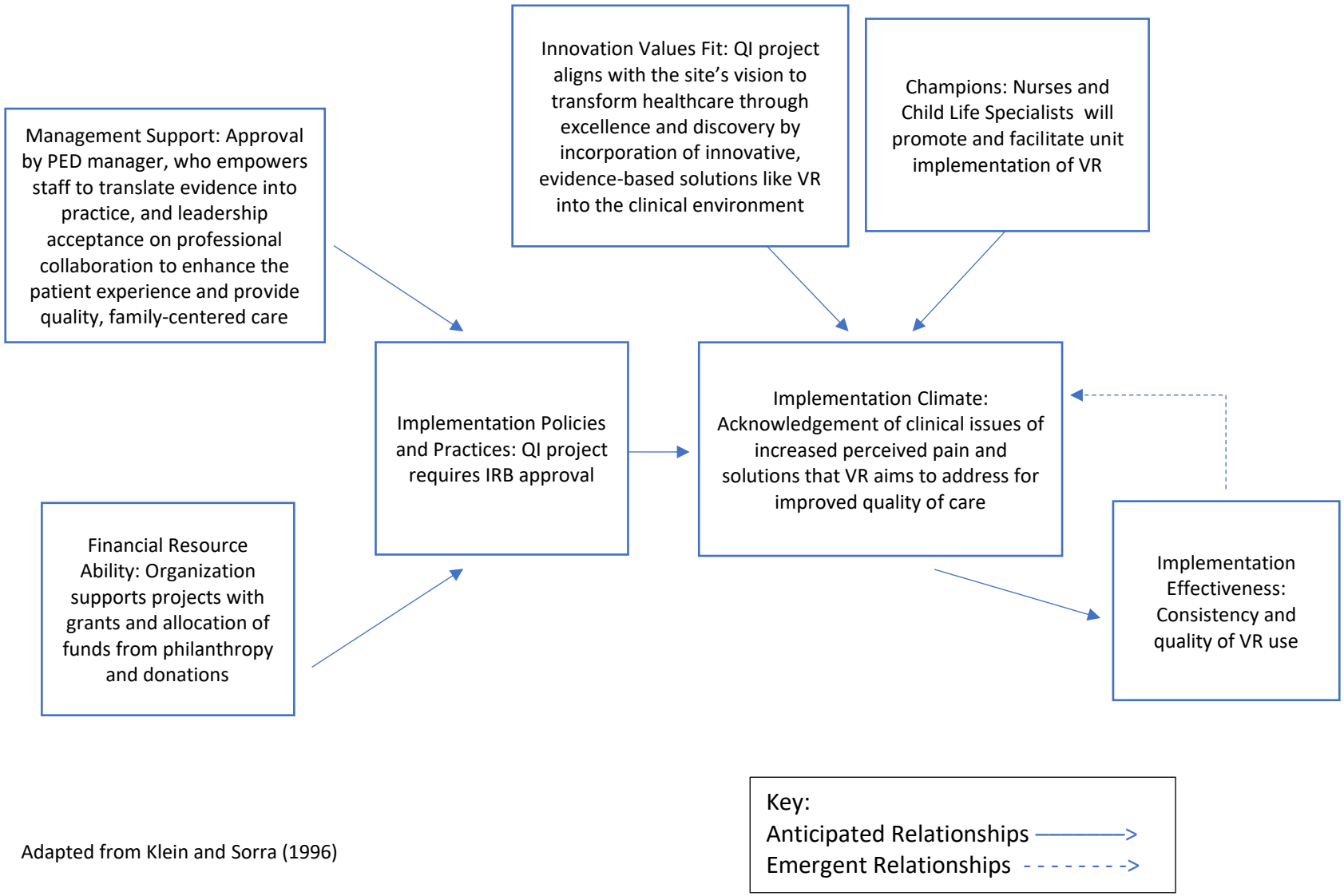


Figure 2

Complex Innovation Implementation Framework



Adapted from Klein and Sorra (1996)

Figure 3

Current process map for patient receiving venipuncture

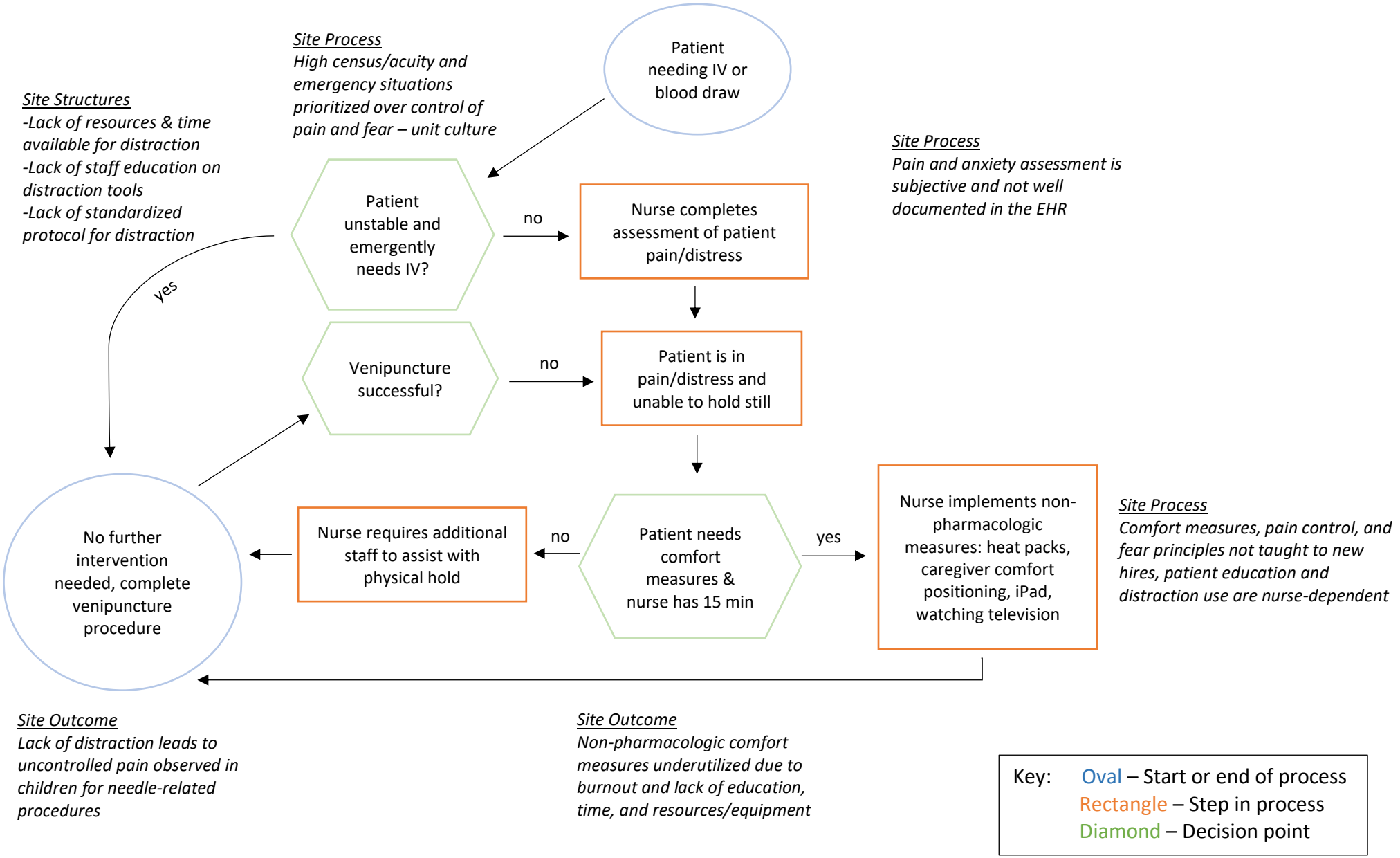


Figure 4

Desired process map for virtual reality use during venipuncture

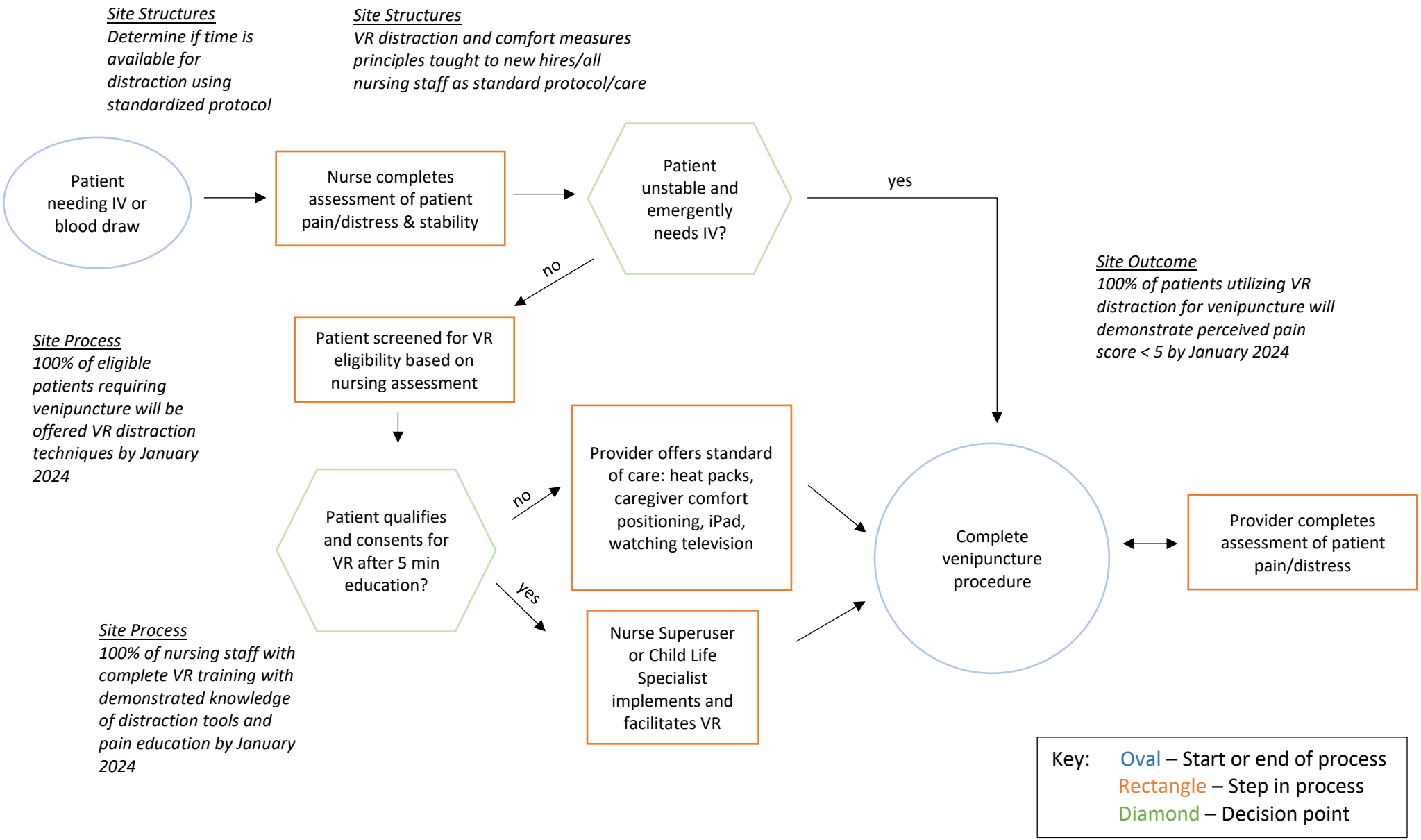


Figure 5

Wong-Baker FACES® Pain Rating Scale [1]

1

[1] Used with permission from the Wong-Baker FACES Foundation.

Figure 6

Role Breakdown for Staff Education

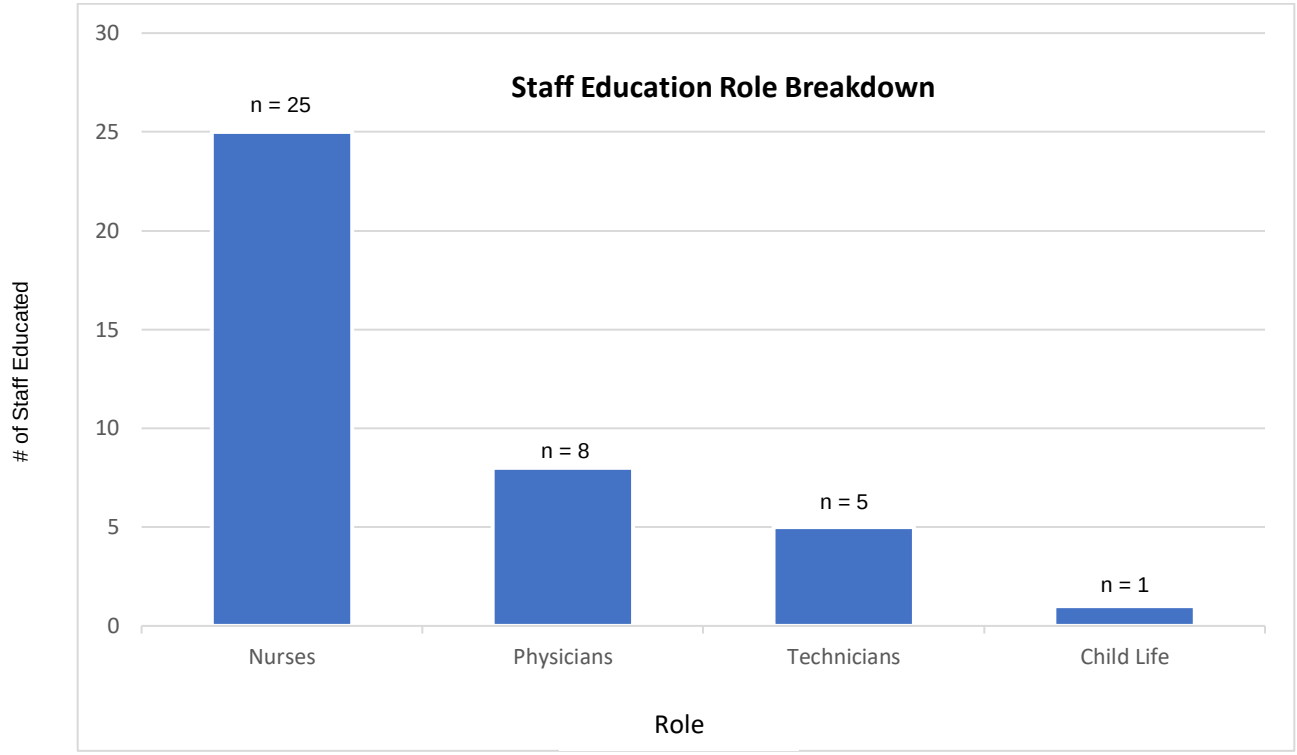


Figure 7

Run Chart of Virtual Reality Utilization for Documented Eligible Patients

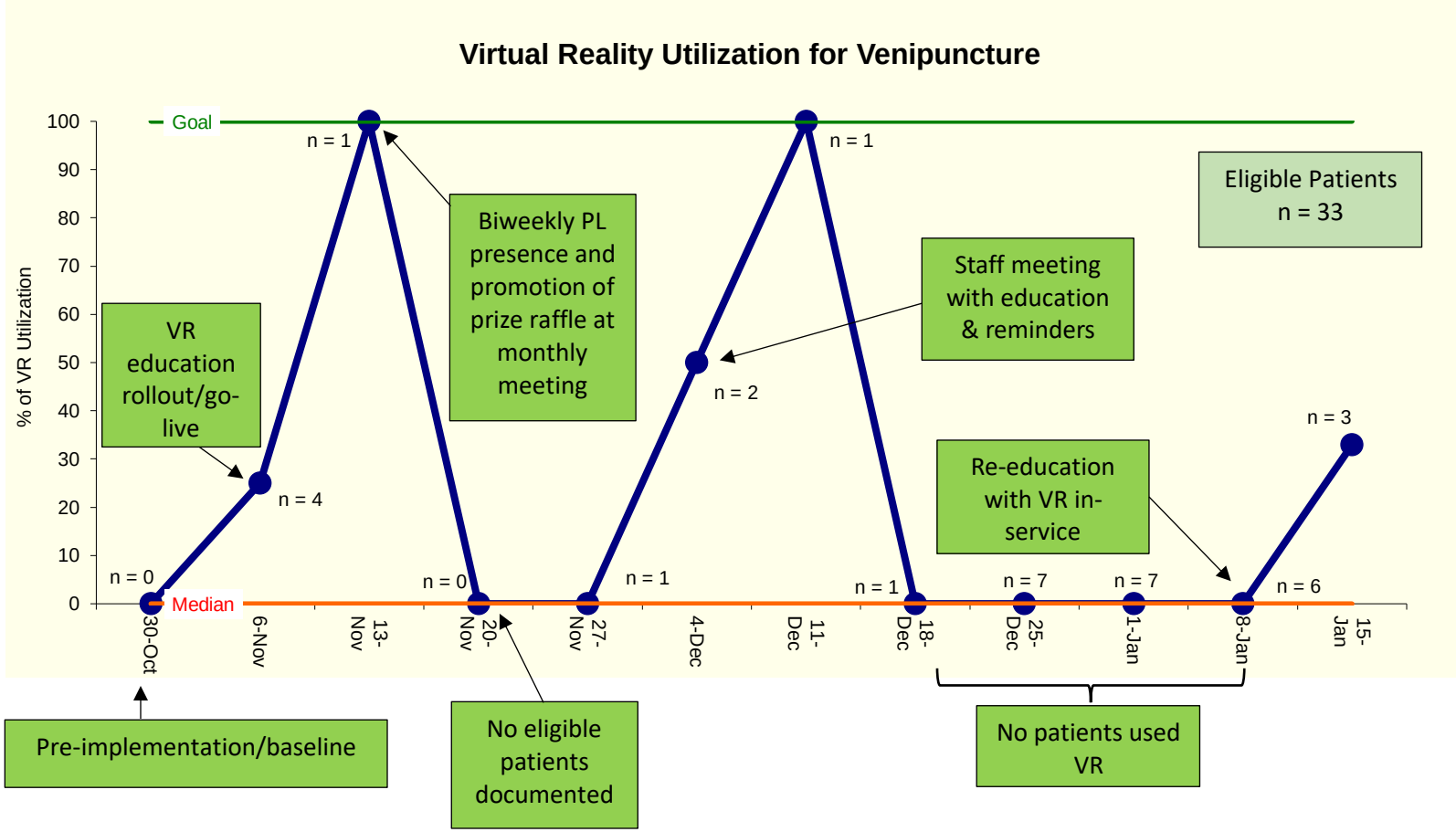
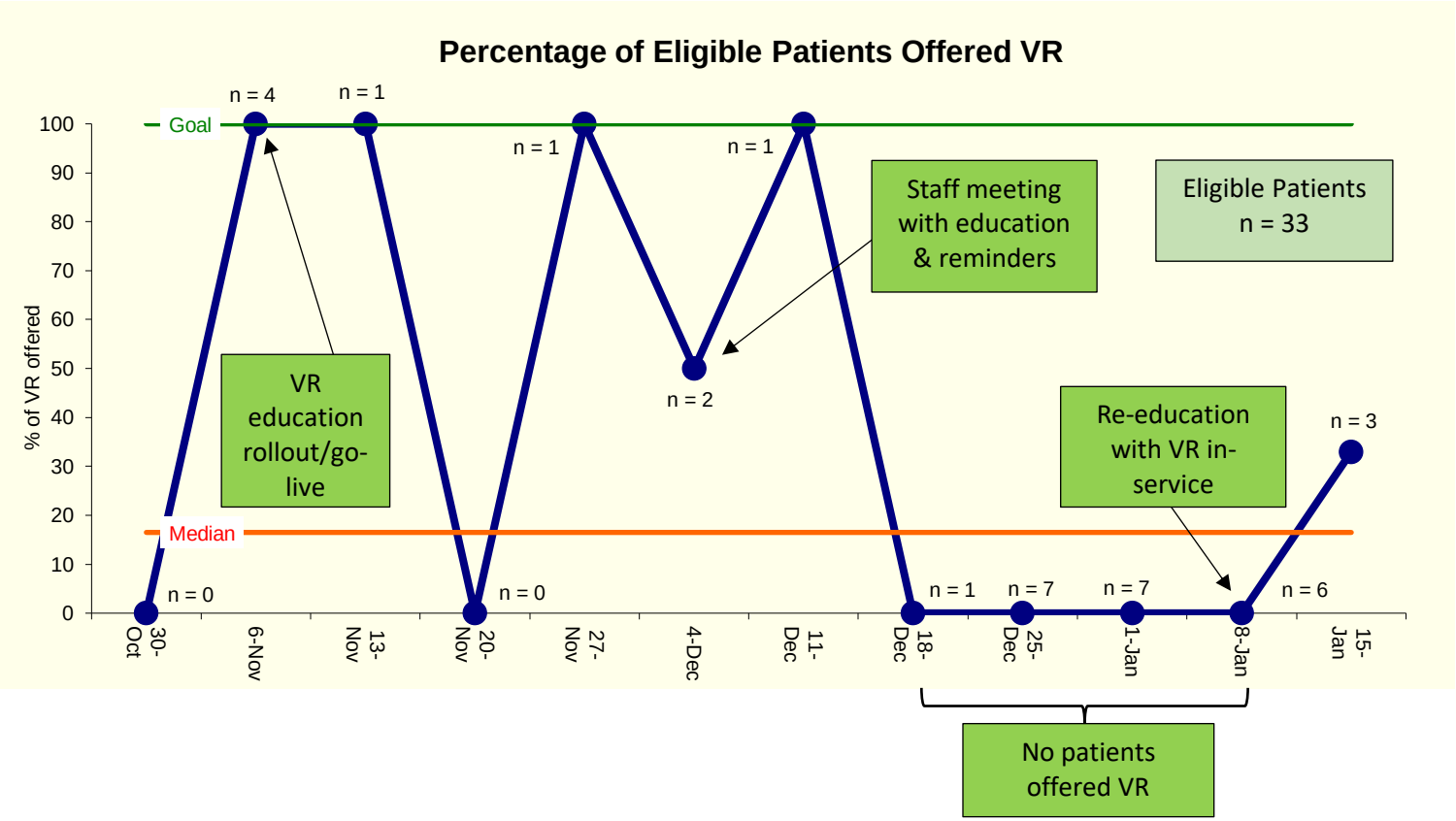


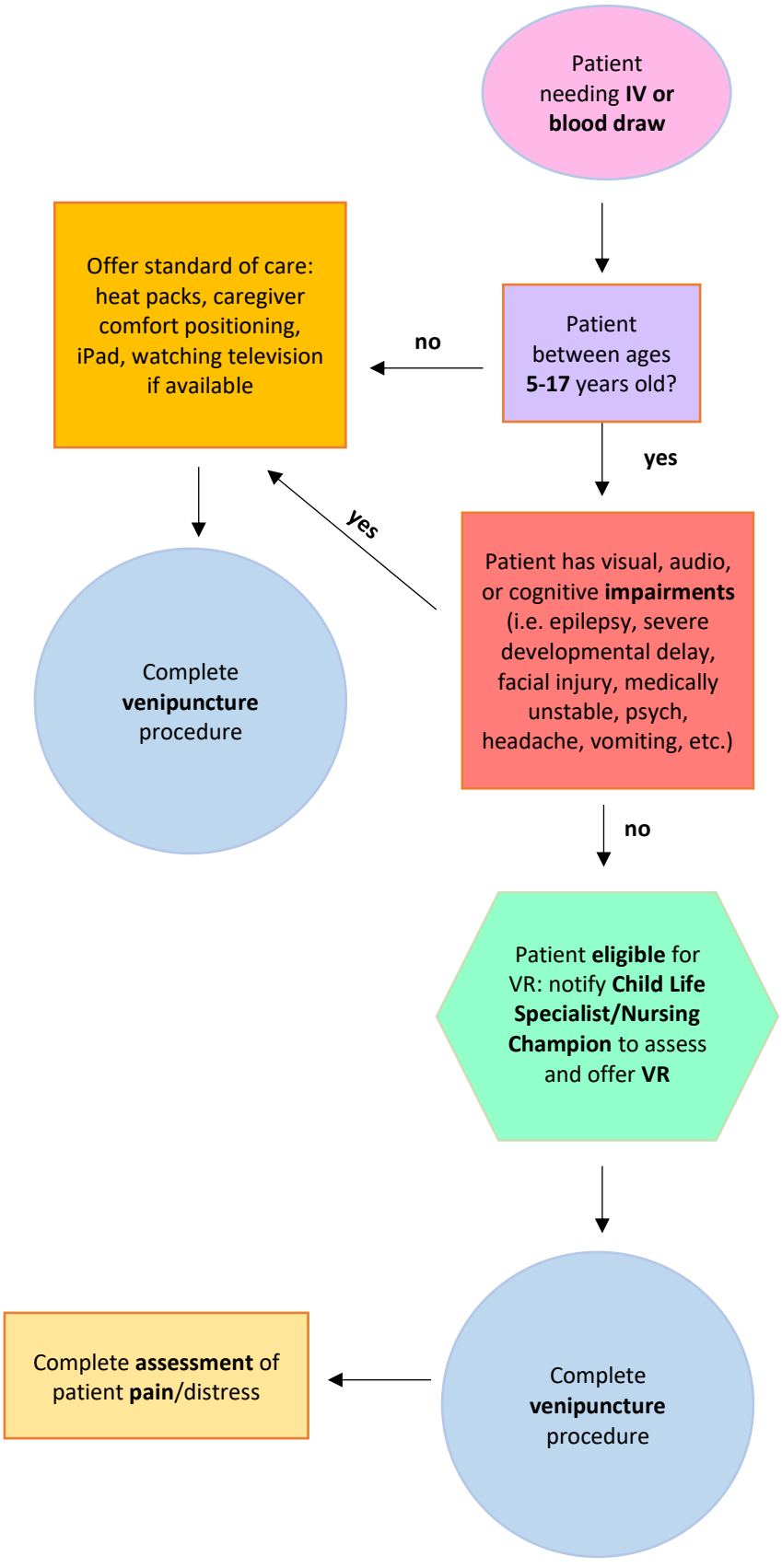
Figure 8

Percentage of Documented Eligible Patients Offered VR



Appendix A

Virtual Reality Eligibility Algorithm



Appendix B

Staff Education

Staff Education VR

Please complete the survey below.

Thank you!

1) Name _____ (First and Last name)

2) Role in PED
- ◯ Nurse
- ◯ Child Life
- ◯ Physician/NP/PA
- ◯ Technician

3) Completion of VR training/in-service and reviewed the algorithm & guide?
- ◯ Yes
- ◯ No

Appendix C

VR Utilization

VR Utilization

Please complete the survey below.

Thank you!

Patient MRN	_____ (Numbers only)
Age Range of Patient	◯ Younger than 5 ◯ 5-6 ◯ 7-8 ◯ 9-10 ◯ 11-12 ◯ 13-14 ◯ 15-16 ◯ 17-18 ◯ Older than 18 (Years)
Date and Time of Procedure	_____
Type of Needle Procedure	◯ IV insertion ◯ Blood draw
VR eligibility algorithm adhered to?	◯ Yes ◯ No
Does the patient have any contraindications to VR?	◯ Yes ◯ No (i.e. epilepsy, severe developmental delay, facial trauma, TBI, psychosis, medically unstable, altered mental status, etc.)
Was VR offered?	◯ Yes ◯ No
Was VR used?	◯ Yes ◯ No
How much pain did the patient report from the needle stick while using VR?	◯ 0 no hurt ◯ 1 ◯ 2 hurts little bit ◯ 3 ◯ 4 hurts little more ◯ 5 ◯ 6 hurts even more ◯ 7 ◯ 8 hurts whole lot ◯ 9 ◯ 10 hurts worst
Was procedure successful?	◯ Yes ◯ No