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Burns

# Analgesic Use of Virtual Reality for Burn Dressing Changes in Low- and Middle-income Countries: A Feasibility Study

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**Background:** The paucity of pain management options in resource-limited settings is a significant and systemically unaddressed problem. To improve global health equity, it is important to bridge this gap in care without introducing the peril of opioid dependence. We present a proof-of-concept case series wherein virtual reality (VR) was successfully used to manage discomfort in patients undergoing burn dressing changes in sub-Saharan Africa.

**Methods:** Nine patients presenting with burn injuries of variable severity underwent routine stabilization and dressing as part of standard-of-care treatment. During dressing changes, a VR intervention consisting of the *Dream Flight* interactive game displayed on an Oculus Quest 2 headset was offered to patients. Patient mood scores were collected before VR initiation and at the conclusion of the dressing change by a translator using the Youth Feelings Scale.

**Results:** There were no adverse events associated with use of the VR headset and no patients elected to terminate the VR during their procedure. Patients and physicians subjectively reported satisfaction with the device's utility in the procedure. Before VR initiation, the 95% confidence interval for patient mood score was 4.89 ± 1.725. After VR initiation, the 95% confidence interval for patient mood score was 8.78 ± 1.40.

**Conclusions:** Our results of this proof-of-concept case series to suggest both feasibility of use and positive influence on patient discomfort and periprocedural satisfaction. We propose that VR should be explored as an analgesic alternative and/or adjunct to narcotics in resource-limited countries, particularly for high-pain, low-duration procedures. *(Plast Reconstr Surg Glob Open 2024; 12:e6226; doi: 10.1097/GOX.0000000000006226; Published online 11 October 2024.)*

## INTRODUCTION

The dearth of pain management options in low- and middle-income countries (LMICs) is a significant and systemically unaddressed problem. Approximately six billion people live without access to analgesics capable of managing even moderate pain.[1] Unmanaged pain, and the stress and subsequent disability it places on patients, represents a significant burden to local socioeconomic and medical systems. To improve global health equity, it is important to bridge this gap in care, without introducing the peril of opioid dependence.[1,2]

Among the most common, but also most painful and challenging to manage conditions in LMICs are burns. The necessary regularity of dressing changes places increased strain on patients and caregivers, whereas the extreme pain felt by the patient—as much as a 40% increase from the injury baseline—demands effective management, particularly in young patients.[3] Although burn dressing changes are challenging even in high-income countries (HICs), their difficulty is compounded further by lack of adequate analgesic options in LMICs.[2] Limited access to narcotic and sedative medications increases the discomfort and anxiety associated with these treatments for patients and caregivers alike.[1]

A promising nonpharmacological approach to pain management is virtual reality (VR).[4] VR works by

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immersing the patient in artificial stimuli via a visual and/or auditory display.[5] In HICs, VR has been used for pain relief in a number of clinical interventions including intravenous procedures, dental procedures, chemotherapy, and dressing changes.[6–12] The analgesic effects of VR are thought to stem from distraction: by shifting the patient's attention away from the procedure they are undergoing, focus is placed on VR-associated stimuli, and the pain signal is partially ignored.[5] Additionally, studies using magnetic resonance imaging and electroencephalography have shown that in some patients, and VR can induce neurophysiological and neurochemical changes such as decreased P2 amplitude and increased prestimulus spontaneous gamma oscillations mirroring those in exposure therapy, suggesting that multiple pain-controlling mechanisms exist.[4–6]

VR has been extensively studied in HICs, but it has not been explored in LMICs due to concerns about cost and complexity of implementation.[2] However, VR has become increasingly available and inexpensive over recent years, creating the opportunity for impactful utilization in a previously unexplored setting. Studies have shown that VR does not decay in its effectiveness as a pain reliever with repeated use, a characteristic that makes VR well-suited to use in the global-medicine setting.[11] VR has played an increasing role in the treatment of burn patients in the United States and has been greeted with high patient satisfaction and minimal side effects.[13–17]

We present a feasibility study of VR use for pain management in patients undergoing burn dressing changes in sub-Saharan Africa. Based on our results, we propose that VR should be explored as an analgesic alternative and/or adjunct to narcotics in LMICs, particularly for high-pain, low-duration procedures in young patients.

**Takeaways**

**Question:** Is virtual reality (VR) technology an efficacious means of managing pain in patients undergoing burn dressing changes in an analgesic-scarce setting?

**Findings:** VR was successfully used to manage pain and anxiety in nine primarily teenage patients undergoing burn dressing changes in sub-Saharan Africa.

**Meaning:** VR should be explored as an analgesic alternative/adjunct to narcotics in resource-limited countries, particularly for high-pain, low-duration procedures.

## METHODS

Patients were identified from burn patients undergoing in-patient care at the Hospital Central de Maputo, Mozambique. The VR headset was used during a surgical outreach trip in August 2023 to the site by Ohana One, a nonprofit organization focused on providing surgical education and care in LMICs. During dressing changes, VR intervention consisting of the *Dream Flight* (Refugio3D) interactive game displayed on an Oculus Quest 2 headset (Meta, Menlo Park, Calif.) was offered as an option to patients. A translator was used to explain the purpose of the project to patients and their families, and they were given the opportunity to participate. Exclusion criteria included patients with vertigo, motion sickness, or claustrophobia. Informed consent from the parents and assent by participants was obtained via the translator. The study was approved by the local hospital administration and ethics committee.

*Dream Flight* requires only head movements to participate, making it ideal in a procedural setting where the patient is otherwise required to remain still (Fig. 1). Although wearing the VR headset, patients watch a paper airplane fly through various levels of scenery accompanied by music. The user is able to control the plane from a third-person perspective to follow a path of crystals. This single VR environment was used in all cases. Medical staff managed game selection and setup to avoid clinical workflow delays. A training session on VR use was provided to the staff before study onset to familiarize them with the technology and minimize disruptions to clinical workflow. Given time restraints during dressing changes, separate training sessions were not provided to the patients before use during their dressing.

During the course of the dressing change, patients were allowed to engage with the VR game as they wished:

**Fig. 1.** A patient undergoing lower-body dressing changes with a VR headset.

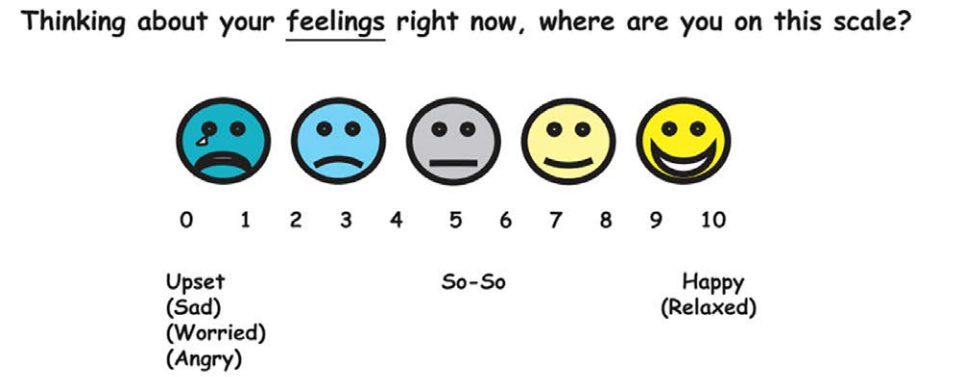


**Fig. 2.** Youth Feelings Scale.

**Table 1. Patient Demographics and Burn Severity**

| Patient No. | Age (y) | Sex | Total Body Surface Area (%) | Affected Region | Duration of Treatment (wk) |
|---|---|---|---|---|---|
| 1 | Teenage | M | 18 | Lower body | 4 |
| 2 | Teenage | M | 36 | Lower body | 4 |
| 3 | Teenage | M | 40 | Trunk | 3 |
| 4 | Teenage | M | 20 | Lower body, trunk | 3 |
| 5 | Teenage | M | 45 | Trunk, arms | 4 |
| 6 | 44 | F | 36 | Trunk | 2 |
| 7 | 16 | F | 18 | Trunk | 2 |
| 8 | 14 | M | 54 | Trunk, lower body, arms | 5 |
| 9 | 3 | F | 22.5 | Trunk, arms | 3 |

with some patients choosing to actively influence the game whereas others passively observed. Headsets were sanitized and charged between each use.

Patient mood scores, queried as fear and anxiety, were collected before VR initiation and at the conclusion of the dressing change by the translator using the Youth Feelings Scale. Similar pictorial mood scales have been validated in previous pediatric populations as well as in cross-cultural studies for use in sub-Saharan Africa.[18] In this scale, a lower score indicates a worse mood or greater fear and anxiety (Fig. 2). Microsoft Excel (Microsoft, Redmond, Wash.) was used to perform a two-tailed paired *t* test to assess pain data pre- and postprocedurally with statistical significance set to an $\alpha$ value of 0.05.

## RESULTS

Nine patients with burn injuries of variable severity underwent dressing changes accompanied by VR treatment. Total body surface area burned ranged from 18% to 54%. All patients in the burn unit at the time of the study were offered participation regardless of age. With the exception of one patient, all participants were younger than 18 years, although specific age was collected in only four of nine patients. This age demographic is representative of regional trends in burn injuries, where children and teenagers are disproportionately affected. Burn distribution also mirrored regional trends with the majority of burns involving the trunk and extremities, which tended to occur from accidental falls on open fires. No patients had burns to the head or neck which might impair use of the headset. Patient demographics are listed in Table 1.

All patients had been previously initially debrided and were undergoing routine dressing changes. The number of prior weeks of treatment varied by patient and is included in the demographic table. Due to scarcity, local standard-of-care treatment for dressing changes did not routinely include pain medication. The VR was used for a single dressing change for each patient.

Before VR initiation, the 95% confidence interval for patient mood score was $4.89 \pm 1.725$. After VR initiation, the 95% confidence interval for patient mood score was $8.78 \pm 1.405$. A two-tailed paired *t* test was performed on the mood data and yielded a *P* value of 0.004 (Fig. 3).

Average length of treatment was 25 minutes. There were no adverse events associated with use of the VR headset, including claustrophobia or vertigo. No patients elected to terminate the VR during their procedure. Patients subjectively reported satisfaction with the intervention and a desire to continue using it, although no formal satisfaction measures were recorded.

## DISCUSSION

In this proof-of-concept case series, we report the successful implementation of VR as an analgesic during burn dressing changes. Patients consistently had positive responses to VR over the course of treatment. Of the nine patients, seven had increases in mood score after VR distraction and two had neutral responses.

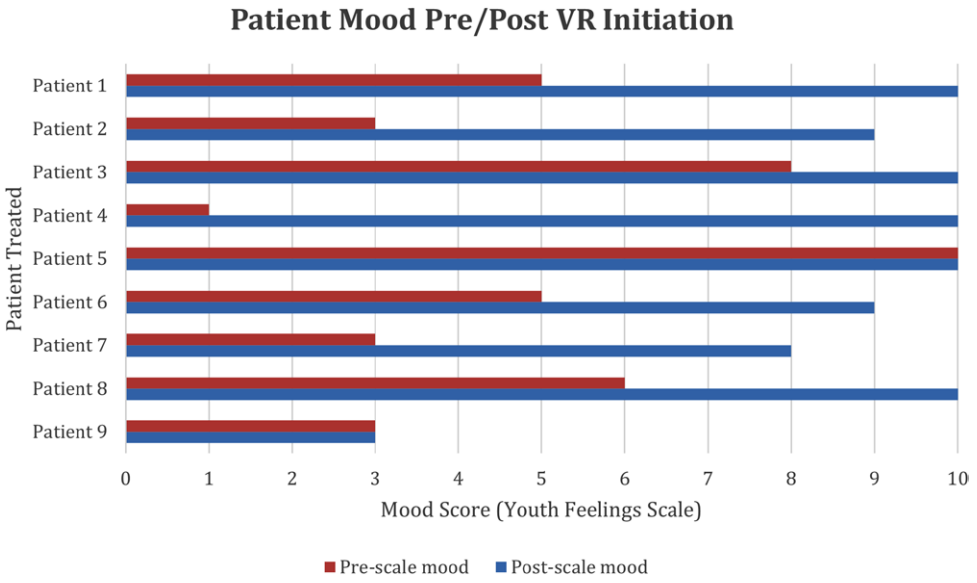


**Fig. 3.** Patient reported mood scores before and after VR intervention.

None of the study patients reported a decrease in mood after VR initiation (Fig. 3). Of the two patients who showed neutral responses, one experienced minimal pain and reported high mood scores before and after. The other patient was 3 years old, and physicians noted that this young patient was somewhat confused by the headset and was less immersed than other patients. We feel that this was more influenced by the headset itself than the video display, as visual distraction has been an established tool in pediatric interventions.[19] The lack of response in this patient suggests that although there is merit in applying visual distraction in a pediatric setting, some very young patients may be better served with a screen rather than headset or with a different type of visual display (ie, cartoon).

Information on the stage of burn healing and the number of prior dressing changes performed for individual patients was not available, which could have significantly impacted the patient's pain and anxiety related to dressing change procedures. Change in mood also represents an imprecise metric of efficacy for pain reduction, as improvements in mood at the end of the procedure could be due in part to relief from completion of the procedure itself. The Youth Feelings Scale was chosen for its cross-cultural validity and the fact that mood more holistically captures the patient's perception of the experience.

Although not formally collected, perception of the intervention was positive among providers as well. Physicians reported ease of use, minimal disruption to clinical workflow, and decreased personal stress around performing the procedure. Another component of VR technology in the LMIC health setting is circumstantial use. Study personnel observed use of the VR headsets by parents of pediatric patients, as well as by nursing staff. Anxiety reduction experienced by caregivers in the high-stress medical setting may also contribute to positive outcomes for the pediatric patients. It follows that the presence of VR technology in-clinic in LMICs may have secondary and tertiary nonclinical effects.

## LIMITATIONS

The study has several limitations, including small sample size and a focused population of primarily teenage burn patients, which potentially limits the study's applicability to other populations. Limitations also existed with respect to details of the medical records. Burn depth, for example, was not recorded, which could impact the patient's pain level and experience with dressing changes. Each patient also only utilized the headset once, so subsequent data were not available for comparison. This was necessitated by the time constraints of the mission setting, which similarly did not allow for an orientation session for patients on use of the technology before use during their dressing changes. Prior familiarization with the technology could help with patient comfort as well as clinical efficiency; however, we feel that the single use of the technology did not diminish its impact. Conversely, as none of the patients had previously used VR, improved mood scores could be due to the novelty of the intervention rather than its impact on pain. Other studies have raised concerns for a dampening effect with repeated exposure to VR but found this not to be the case.[20] We plan for future studies with greater numbers of patients and evaluating repeated exposures over serial dressing changes. Prior familiarization with the technology could also help with patient comfort as well as clinical efficiency.

Additionally, no control data from the patients receiving dressing changes without VR were recorded, which limit the ability to prove efficacy of the intervention above standard of care. We similarly plan to collect additional data with a control group with future studies. Finally, comparisons between opioid-naive and opioid-exposed patients would provide valuable information on the

impact of VR as an analgesic; however, this was not possible in the current setting as opioids were not available. Additionally, studies in settings where opioid medications are more routinely available would be helpful for direct comparison between groups.

Related to the VR headset itself, the cost of the device could represent a barrier to implementation, which we believe has been a historic reason that VR technology has not been previously applied to the LMIC setting. Poor utilization of overly complex or expensive donated technology in low- and middle-income settings has been well established.[21] This is often related to maintenance costs or connectivity or a poor match of local needs to the intervention. Any new technology implemented must carefully consider appropriateness and applicability. However, we feel that this does not mean the new and evolving technologies do not have a place in low-resource settings. The Oculus headset used in this study now costs US $249.99 and is a fully self-contained system, not dependent on local internet, eliminating any concerns regarding local connectivity.[22] Lifespan of the device is dependent on care, but per manufacturers should last 2–5 years depending on use, and should not require any routine maintenance. There were no issues related to malfunction or maintenance during the study period. Although we do not minimize that the price may still represent a significant cost in a resource-limited setting, we also feel that VR is a technology that has been previously overlooked in low-resource settings out of an assumption of its overcomplexity, but we hope to show with this study that it is in fact an appropriate and promising technology for such settings.

## CONCLUSIONS

Providing adequate analgesia during painful procedures is a major challenge in LMICs with medication scarcity placing strain on patients and physicians alike. Although VR was previously considered an overly complex and costly technology for limited resource settings, recent product advances have made VR more accessible and less expensive. We present a case series wherein VR was successfully used to to improve pain and anxiety in patients undergoing burn dressing changes in sub-Saharan Africa. We demonstrate both feasibility of use and positive influence on both patients and caregivers and present this as a proof-of-concept study to promote further research into analgesic use of this technology in LMICs. Further work is ongoing with our own group for collection of control procedures without VR, use of VR over multiple sessions, and use in the acute postburn debridement setting.

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## DISCLOSURE

*The authors have no financial interest to declare in relation to the content of this article.*

## PATIENT CONSENT

*The patient provided written consent for the use of his image.*

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## REFERENCES

1. Scholten WK, Christensen AE, Olesen AE, et al. Quantifying the adequacy of opioid analgesic consumption globally: an updated method and early findings. *Am J Public Health*. 2019;109:52–57.
2. Morriss WW, Roques CJ. Pain management in low- and middle-income countries. *BJA Educ*. 2018;18:265–270.
3. Tarantino DP. Burn pain and dressing changes. *Tech Reg Anesth Pain Manag*. 2002;6:33–38.
4. Li A, Montaño Z, Chen VJ, et al. Virtual reality and pain management: current trends and future directions. *Pain Manag*. 2011;1:147–157.
5. Gupta A, Scott K, Dukewich M. Innovative technology using virtual reality in the treatment of pain: does it reduce pain via distraction, or is there more to it? *Pain Med*. 2018;19:151–159.
6. Wiederhold MD, Gao K, Wiederhold BK. Clinical use of virtual reality distraction system to reduce anxiety and pain in dental procedures. *Cyberpsychol Behav Soc Netw*. 2014;17:359–365.
7. Li J, Yang H, Xiao Y, et al. The analgesic effects and neural oscillatory mechanisms of virtual reality scenes based on distraction and mindfulness strategies in human volunteers. *Br J Anaesth*. 2023;131:1082–1092.
8. Dunn A, Patterson J, Biega CF, et al. A novel clinician-orchestrated virtual reality platform for distraction during pediatric intravenous procedures in children with hemophilia: randomized controlled trial. *JMIR Serious Games*. 2019;7:e10902.
9. Gold JI, Kim SH, Kant AJ, et al. Effectiveness of virtual reality for pediatric pain distraction during i.v. placement. *Cyberpsychol Behav*. 2006;9:207–212.
10. Furman E, Jasinevicius TR, Bissada NF, et al. Virtual reality distraction for pain control during periodontal scaling and root planning procedures. *J Am Dent Assoc*. 2009;140:1508–1516.
11. Nunna M, Dasaraju RK, Kamatham R, et al. Comparative evaluation of virtual reality distraction and counter-stimulation on dental anxiety and pain perception in children. *J Dent Anesth Pain Med*. 2019;19:277–288.
12. Schneider SM, Kisby CK, Flint EP. Effect of virtual reality on time perception in patients receiving chemotherapy. *Support Care Cancer*. 2011;19:555–564.
13. Hoffman HG, Patterson DR, Carrougher GJ, et al. Effectiveness of virtual reality-based pain control with multiple treatments. *Clin J Pain*. 2001;17:229–235.
14. Bermo MS, Patterson D, Sharar SR, et al. Virtual reality to relieve pain in burn patients undergoing imaging and treatment. *Top Magn Reson Imaging*. 2020;29:203–208.
15. Das DA, Grimmer KA, Sparnon AL, et al. The efficacy of playing a virtual reality game in modulating pain for children with acute burn injuries: a randomized controlled trial [ISRCTN87413556]. *BMC Pediatr*. 2005;5:1.
16. Morris LD, Louw QA, Grimmer-Somers K. The effectiveness of virtual reality on reducing pain and anxiety in burn injury patients: a systematic review. *Clin J Pain*. 2009;25:815–826.
17. Upton D, Andrews A. The impact of stress at dressing change in patients with burns: a review of the literature on pain and itching. *Wounds*. 2014;26:77–82.
18. Huang KT, Owino C, Vreeman RC, et al. Assessment of the face validity of two pain scales in Kenya: a validation study using cognitive interviewing. *BMC Palliat Care*. 2012;11:5.

19. Gates M, Hartling L, Shulhan-Kilroy J, et al. Digital technology distraction for acute pain in children: a meta-analysis. *Pediatrics*. 2020;145:e20191139.
20. Huang Q, Lin J, Han R, et al. Using virtual reality exposure therapy in pain management: a systematic review and meta-analysis of randomized controlled trials. *Value Health*. 2022;25:288–301.
21. Labrique AB, Wadhwani C, Williams KA, et al. Best practices in scaling digital health in low and middle income countries. *Global Health*. 2018;14:103.
22. Meta Store. Meta quest 2: immersive all-in-one VR headset. Available at https://www.meta.com/quest/products/quest-2/. Accessed January 11, 2024.