

Reducing pain during wound dressings in burn care using virtual reality: a study of perceived impact and usability with patients and nurses.

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1 **Title**

2 Reducing pain during wound dressing in burn care using VR: A study of perceived impact
3 and usability with patients and nurses.

4 **Abstract**

5 Burns patients often suffer severe pain during interventions such as dressing changes, even
6 with analgesia. Virtual Reality (VR) can be used to distract patients and reduce pain.
7 However, more evidence is needed from the patients and staff using the technology about its
8 use in clinical practice and the impact of different VR strategies. This small-scale qualitative
9 study explored patient and staff perceptions of the impact and usability of active and passive
10 VR during painful dressing changes. Five patients took part in three observed dressing
11 changes - one with an active VR scenario developed for the study, one with passive VR and
12 one with no VR - following which they were interviewed about their experiences. Three
13 nurses who performed the dressing changes participated in a focus group. Thematic analysis
14 of the resulting data generated four themes: 'Caution replaced by contentment', 'Distraction
15 and implications for pain and wound care', 'Anxiety, control and enjoyment' and 'Preparation
16 and communication concerns'. Results suggested that user-informed active VR was
17 acceptable to burn patients, helped manage their perceived pain, and was both usable and
18 desirable within the clinical environment. Further testing with larger samples is now required.

19

20 **Key words:** Burn Pain, Wound Care, Virtual Reality, Distraction, Usability, Acceptability,
21 Patient Perspectives, Staff Perspectives, Qualitative Methods.

22 **Introduction**

23 Burns patients often experience severe pain during interventions, such as when wound
24 dressings are changed, combining the pain of treatment with the background pain of tissue
25 damage^{1,2}. Opiates are routinely administered for burn pain³. However, opiates come with
26 side effects⁴ and their effectiveness in managing the pain of procedures, such as dressing
27 changes, has been questioned^{5,6}. Inadequate pain control has detrimental effects on
28 psychological and physical wellbeing^{7,8,9}, patient confidence⁵ and compliance¹⁰. Therefore,
29 evidence suggests other forms of analgesia should be considered. Pain theories, such as Gate
30 Control Theory and neuromatrix theory^{11,12}, highlight the importance of psychological
31 determinants of the pain experience, including perception, attention and anxiety.
32 Interventions, such as hypnosis, which address these determinants, have proved effective in
33 distracting patients⁶.

34 Virtual Reality (VR) as a clinical intervention can also act upon pain perception¹³. VR's
35 'artificial three-dimensional environment'¹⁴ works to increase demands upon attention¹⁵ and
36 reduce cues to pain and anxiety before and during procedures¹⁶. When compared with
37 analgesia alone, VR plus analgesia has been shown to achieve a significant reduction in
38 procedural pain scores^{17,18}, and qualitative reports identify increased relaxation and
39 cooperation, reduced pain and anxiety, and effective communication despite immersion in the
40 VR technology¹⁸. Costs of VR technology are falling, and recent developments have both
41 addressed shortcomings of earlier technology (such as nausea) and improved VR's
42 applicability to the clinical area^{5, 19, 20}.

43 Based on dissatisfaction with current methods of pain control and a growing evidence base
44 for the effectiveness of VR, reviewers have recommended its introduction to burn care and
45 rehabilitation²¹. However, further detailed work is required to explore specific influential
46 variables by considering the impact on different patient groups of different VR
47 environments²². VR environments may need tailoring to specific groups for maximum

48 effect²³, for example, using ‘cold’ scenarios for burn patients, and developing different VR
49 scenarios to suit children of different ages¹⁸. One variable of interest is the degree of
50 immersion offered by the intervention.^{1,22, 19, 24} VR can offer active involvement for the user,
51 or a passive experience of simply watching and listening. Tashjian et al. reported
52 significantly greater reductions in pain when patients were involved in an active VR scenario
53 via headset, compared with the passive experience of watching a video by the bed²⁵.
54 However, given the differences between the two interventions, it was unclear to what extent
55 whether the result was achieved through the active vs. passive element alone²⁶

56 A recent study conducted by the Authors (2018) developed user-informed scenarios based on
57 active and passive VR and compared their effects on the experimental pain of a cold pressor
58 test. Experimental pain studies offer greater variable control: participants can be administered
59 the same pain stimulus and intervention, which makes it easier to distinguish the effects of
60 the target variables on outcomes. Previous results have shown that experimental pain is lower
61 with VR^{24,27,-28}. Our study supported these findings, demonstrating significant differences
62 between VR conditions overall and the no-VR baseline in both pain threshold (the point at
63 which pain was first experienced) and pain tolerance (the point at which the cold pressor pain
64 became intolerable and participants removed their hand). In addition, findings showed that
65 pain threshold was significantly higher in active, immersive VR conditions than passive ones.
66 When results for active and passive scenarios were considered separately, significant
67 differences from baseline were only demonstrated for the active condition. The small sample
68 size is acknowledged; however these results indicated that the most effective form of VR in
69 managing pain for this sample was an active, immersive experience (Authors, 2018).

70 Findings regarding VR - and especially immersive VR - in experimental pain relief are
71 encouraging; however, experimental pain is relatively mild, of limited duration, escapable,
72 and implies no health threat. It is not clear whether the effects on pain can be said to transfer

73 easily into the clinical environment²². Patients' types and levels of clinical pain are likely to
74 differ, and their medical needs often influence how an intervention can be delivered²². It is
75 therefore important that VR be trialled in the clinical arena to confirm its real world usability
76 and effectiveness. The current study applied the VR interventions developed and trialled in
77 our experimental pain trial to a small sample of burn inpatients undergoing regular dressing
78 changes at a single UK Burns Unit. Approaching people who will actually use the
79 intervention - patients and staff - has been described as a 'person-centred' approach which
80 enhances the evidence base for intervention development and feasibility²⁹. The work was
81 supported by a Medical Research Council Confidence in Concept grant [number will be
82 supplied after blind review].

83 Aims

84 This study aimed to explore:

85 - patient and staff perceptions of the effect of active and passive VR on perceived pain and
86 anxiety during painful dressings changes;

87 - patient perceptions of the usability, acceptability, engagement with active and passive VR
88 scenarios;

89 - staff perceptions about the usability and implications of the VR technology within a Burns
90 Unit inpatient setting.

91 Methods

92 Design

93 This was a small-scale qualitative usability study, employing qualitative methods in keeping
94 with the person-centred approach to intervention development and feasibility work²⁹.

95 Review and Approval

96 The original study protocol was reviewed by the Patient and Public Involvement (PPI) Panel
97 for the Directorate of Therapeutics and Palliative Care, [City] Teaching Hospitals NHS
98 Foundation Trust, and their suggestions were followed. Ethical approvals for the trial as
99 described were granted by The University Research Ethics Committee and NHS Research
100 Ethics Committee (IRAS 221071).

101 Participants

102 Patients: Participants were adult inpatients at the local Burns Unit who were undergoing
103 regular dressing changes during the study period. Exclusion criteria included head and neck
104 burns, wound infection, current diagnosis of PTSD, active psychotic symptoms or high levels
105 of distress. Suitable patients were briefly introduced to the study and supplied with a full
106 information sheet, with details about aims, procedures and rights. Before taking written
107 consent, participants were encouraged to try out a short VR experience. We aimed to recruit
108 up to 10 participants, in keeping with similar intervention development and usability studies³⁰
109 Five patient participants were recruited during the time available. Hospital stays which were
110 too brief for the trial, mental health problems, injury location and infection control problems
111 were key factors in those who were not eligible or declined participation. Participant details
112 are provided in Table 1.

113 TABLE 1 HERE

114 Staff: Three qualified (female) nurses who had been directly involved in the care of
115 participating patients were invited to and participated in a short post-study focus group, to
116 share their impressions of the VR technology, its impact, usability and acceptability.

117 Materials

118 Equipment: An Oculus Rift CV1 headset, PC and digital recorder.

119 VR Scenarios: From the four tested under experimental conditions (Authors, 2018), we
120 offered participants a choice two active VR scenarios, both of which had proved effective.
121 These were named 'Basket' and 'Flocker'. In Flocker the user-controlled character was
122 engaged in herding sheep through various obstacles. Basket was an energetic scenario based
123 on in which the user was involved making basketball shots and building up their score. As
124 described in Authors (2018) these scenarios were developed by a games designer, following a
125 consultative workshop which included burn survivors, games designers, clinical and
126 academic psychologists. As described above, they were trialled under experimental
127 conditions and proved acceptable and enjoyable to users, and effective in reducing perceived
128 pain. As a passive VR experience, participants were offered a choice of videos from the
129 Oculus video application, which included scenes such as seeing the world from the viewpoint
130 of an eagle, swimming with dolphins, or exploring a space station.

131 Procedure

132 Patients took part in three observed dressing changes during the study - one without VR, one
133 with an active VR scenario and one with the passive VR scenario. The order of dressing
134 changes was altered between participants, as shown in Table 1. Decisions about the suitable
135 timing of each were made between the patient, the clinical team and the researcher, and the
136 order was varied between the five participants. IP spent time with the participant before,
137 during and after the dressing. He prepared the equipment, provided instruction and facilitated
138 short familiarisation sessions for the patients before they used each scenario. Dressings
139 ranged from 12 minutes (P5, active VR) to 70 minutes (P3, active VR) in length, with most
140 lasting between 25 and 40 minutes.

141 Data Collection

142 Patient Interviews: IP conducted interviews at the bedside following completion of the two
143 observed VR dressing changes once participants were comfortable. Questions included such
144 as 'How was your pain during the dressing change while you were in the VR environment?'
145 'How did you feel generally during the experience?' and 'How helpful did you find the VR
146 during the dressing change?' IP conducted a second interview with each participant at the end
147 of the study, to gather overview data, with questions such as, 'Which VR experience did you
148 prefer and why?' and 'From your experience how does a dressing change under VR compare
149 with one with no VR experience?'

150 Staff Focus group: PF conducted the staff focus group. It took place in a private room near
151 the ward and was audio-recorded. Questions focused on staff members' experience, their
152 sense of the patient experience, and their general impressions of the VR technology. Items
153 included: 'How did the VR dressing changes differ, if at all, from the dressing change without
154 VR?'; 'What do you think the patients' experience was of the VR dressing change?'; 'What
155 have the difficulties or complications been when using this technology?' and 'On balance, do
156 you feel this sort of intervention is beneficial; if so / if not, why?'

157 Analysis

158 Data from staff and patients were transcribed and anonymised. For example, nurses were
159 identified by ns1, ns3, etc., and patient participants by pt2, pt4, etc.

160 Transcripts were analysed for themes using an in-depth inductive coding, thematic mapping
161 and theme development process³¹. This was a semantic analysis, in which the focus was data
162 content (rather than underlying assumptions) and interpretation involved identifying the
163 significance and implications of themes and constituent data in the context of existing
164 knowledge³¹. Themes were refined through constant comparative analysis within and
165 between transcripts and then across the whole dataset. Key themes reflected what seemed to

166 be important aspects of the experience of VR among participants. PF acted as primary
167 analyst, and themes were shared, discussed and refined through discussion with all authors.

168 Results

169 Four themes were generated from the combined dataset from patients and nurses: *Caution*
170 *replaced by contentment*, *Distraction and implications for pain and wound care*’, *Anxiety,*
171 *control and enjoyment*’ and *Preparation and communication concerns*’.

172 *Caution replaced by contentment*

173 This theme reflected how participants’ initial reluctance regarding VR had given way to
174 positive perceptions. Two of the five participating patients initially decided against
175 participating, but later changed their minds, based on the pain they had experienced without
176 VR: *‘I didn’t want to, but it did good, and I’m glad I did’* (pt2). The novelty of and her
177 unfamiliarity with VR technology initially caused pt5 anxiety and uncertainty; however, in
178 retrospect, she commented, *‘I don’t think people should be afraid of doing it.’* It is not
179 surprising that people experiencing the combined trauma of burn-injury, hospitalisation and
180 severe pain were anxious and reluctant to take on something new. Nonetheless, these five
181 participants had been willing to try VR and were unanimous that this had been a good idea.
182 After the first VR trial, any initial anxiety had disappeared: as they approached the next VR
183 trial, they were *‘excited to try it’* a second time (pt4).

184 Nurses were similarly impressed with how well VR had worked: *‘Generally my experience*
185 *has been that the VR’s very helpful, very good at distracting’* (ns2). Both groups felt that
186 nurses could *‘sell it more’* to patients, and one person suggested that hearing others’ positive
187 experiences would help. Comments about VR and their experience of it from staff included *‘it*
188 *was all positive’* (ns2), and from patients, *‘great’* (pt5), *‘brilliant’* (pt3, pt4), *‘it’s worth its*

189 *weight in gold'* (pt1) *'now I know what I want for Christmas'* (pt4), and *'If I get any money, I'll*
190 *get one of these'* (pt5). Based on their experience, patients wanted to use VR again for
191 dressing changes, even if this meant paying:

192 *'I will have it, and I would even say, as an option, you know. If people said, this is*
193 *early days, and you had to pay for it, I'd say, right then, I'd pay for it, I'd pay extra for*
194 *that. I would pay, rather than not have it.* (pt3).

195 Staff expressed their wish to be involved with any future funded research, were positive
196 about its future potential and impatient for it to be routinely available in the clinical arena.
197 Both groups suggested additional applications for VR in physiotherapy, rehabilitation,
198 childbirth, chronic pain and disabling conditions.

199 *'Distraction and its implications for pain and wound care*

200 This theme reflected the positive distracting effects of VR, and especially active scenarios,
201 which impacted on pain tolerance and gave nurses scope to do more and spend longer on
202 dressing changes. Additional nuanced data reflected the fluctuations in, and, sometimes,
203 increased pain resulting from more intensive wound care.

204 A key factor in reducing pain and increasing tolerance of wound care seemed to be the degree
205 of distraction created by VR:

206 *'It drags you off. It drags you off, definitely. They are picking off stuff where, say they*
207 *pick one or two off ... you'd be on it, wouldn't you, you're concentrating on the pain*
208 *all the time, where that does help me, it's distracting, the whole thing'* (pt3).

209 Active scenarios were more effective in distracting patients: *'[it was] better with VR; [but]*
210 *scenarios [were] better for taking mind off'* (pt1). In contrast, the relative slowness and
211 passivity of passive version facilitated only a limited degree of distraction for most

212 participants. Four spoke of feeling frustrated by the slowness and passivity of the experience
213 and needing better distraction from the pain. Immersion was further compromised during the
214 passive VR by swooping movements in videos, which induced dizziness and motion sickness
215 in some.

216 Patients were unanimous that they had achieved good levels of distraction (and no nausea) in
217 the active VR. Some spoke of awareness of pain and of what the nurses were doing - *'felt it*
218 *but not concentrating on it'* (pt2) - but their focus remained on the engaging scenario. Nurses
219 spoke of patients being *'amazed'* (ns2) by what they had done afterwards, and several patients
220 reported losing track of time, so immersed had they been in the virtual world: *'It seemed to go*
221 *much quicker than I thought'* (pt5).

222 In addition, wearing the headset and watching the scenario meant patients could not see the
223 wound and nursing activities: *'I didn't see what they were doing ... if I could see what they*
224 *were doing, I wouldn't let them'* (pt1). Without this distraction, normal behaviour involved
225 being drawn to and focusing on the wound and wound care, which increased pain. Not
226 watching meant reduced pain: *'Before you were thinking, it hurts, because watching them do*
227 *it makes it worse'* (pt2).

228 However, data suggested that the distraction of VR actually contributed towards pain in
229 unexpected ways. Participants' greater distraction from and tolerance of pain compared with
230 normal circumstances meant that nurses could spend longer on dressings and carry out more
231 intensive wound care, such as removal of numerous surgical staples and more extensive
232 debridement:

233 *'he was a lot better with the VR on and I did pick quite a lot ... he'd not allowed staff*
234 *to do what we would normally want to do because of the pain, whereas with the VR*
235 *he allowed me to do that'* (ns1).

236 This nurse commented that this patient's pain tolerance allowed her to remove more dead
237 tissue from the wound bed, with a potentially positive impact on healing and infection.
238 Without VR, the dressing change would therefore far more painful, yet with VR he had been
239 able to tolerate it and both he and the nurses were positive about the impact of VR on both
240 pain and wound care. However, pain relief and distraction for all patients came to an abrupt
241 end when the VR was removed after the dressing. A few patients - particularly where wound
242 care was more intensive - complained of lasting pain afterwards in both VR and non-VR
243 trials, as painkillers wore off. Participants suggested offering VR *after* a dressing, to extend
244 the positive distracting and analgesic effects.

245 Although there were reports of pain *after* dressings, perceived pain was clearly reduced
246 during the procedure with active VR. Nurses also believed patients had required less
247 analgesia with VR, but acknowledged the considerable variations brought about by
248 differences in the dressing change intervention and stage of healing, making it hard to
249 attribute this solely to VR:

250 Ns3: *'My patient didn't need any extra analgesia during, before or after the*
251 *dressing change. I think she probably would've liked some otherwise. I think*
252 *she felt she needed some, pre-dressing, and then she didn't.'*

253 Ns1: *'I get the feeling, on the whole, it did reduce it a little bit but then again ...*
254 *different dressing changes are different on the same person as things get*
255 *better.'*

256 This theme reflected the overall positive effects on pain and distraction of VR, and in
257 particular the active scenarios. That it might facilitate intensive wound care and potentially
258 affect post-procedural pain was not fully anticipated. These aspects are worthy of
259 consideration and will be discussed below.

260 *Anxiety, control and enjoyment*

261 This theme included data suggesting that VR had not only reduced negative psychological
262 effects of burns procedures, and had also created positive experiences, which were
263 unexpected. Participants believed that VR had reduced their pre-dressing anxiety before and
264 during their second trial of VR, because of their experience of distraction and its impact on
265 pain, especially in the active condition. Nurses' data were in agreement: their perception had
266 been '*lessened anxiety*' (ns1) and distress from patients during VR dressings. Some suggested
267 offering VR before (as well as during) a dressing change, to reduce anxiety, and on days
268 between dressings to reduce stress.

269 Most spoke of positive emotions in response to the VR. The active VR in particular was '*fun*',
270 '*challenging*', and '*enjoyable*' (various pts). Ns1 expressed surprise at participants' apparently
271 pleasurable engagement with the technology. She spoke about the '*laughter*', an outcome
272 rarely associated with painful dressing changes. Ns2 commented on occasional '*hilarity*' and
273 '*comical*' moments, noting that VR had '*lightened*' the experience for everyone.

274 One concern among eligible patients when deciding to take part was a fear of losing the
275 ability to talk easily with staff, for example, to ask them to stop, when engaged with the VR
276 scenarios. However, among those who actually participated, the technology had the opposite
277 effect: two described feeling they could control part of the otherwise passive and traumatic
278 dressing change experience when using VR. Having control meant retaining one's '*humanity*.'
279 The sense of having some control over the situation, along with the distraction and reduced
280 pain, helped some patients control their own emotional responses to the experience. For
281 example, pt5 spoke of '*trying to be a grown up*' despite the dreadful pain of her burns. The
282 VR, described as a '*crutch*,' meant that, rather than '*howling*' in response to dressing pain, she
283 had found '*something as trivial as a video was actually quite empowering for me because I*

284 *could take myself away'* (pt5). There was a sense of pride in her achievement of self-control
285 in circumstances which could otherwise be experienced as shameful, humiliating and
286 disempowering.

287

288 *Preparation and communication concerns*

289 Preparation and communication emerged as potentially problematic issues which impacted
290 primarily upon the nurses involved, but also by consequence upon the patients themselves. In
291 order to avoid burdening clinical staff, research team members took on the roles of preparing
292 participants for VR, managing the technology during dressing changes, and collecting data.
293 Therefore, although nurses were fully aware of the study, they did not receive training and
294 preparation in the technology. This limited their ability to discuss VR with patients before,
295 during and after its use between researcher visits. Both patients and staff commented that
296 greater staff knowledge would have helped: *'I thought the VR was really good but I didn't*
297 *know a lot about it before the dressing change. I hadn't got a clue how it worked'* (ns2). Both
298 patients and nurses suggested more preparation time (perhaps assisted by trained nurses)
299 would help, for example with *'the physicality of wearing it'* (pt5), or *'a practice with the VR*
300 *pre-dressing, so that they'd know what they'd like to do, what activity, and how to do it'*
301 (ns1). Greater direct involvement in the study could have allowed nurses to play a more
302 active role in preparing, supporting and informing VR users. Learning about the technology
303 together might also contribute towards development of closer staff-patient relationships.
304 Experienced burns staff may lose touch with the novelty of the experience of dressing
305 changes for patients. Shared unfamiliarity with and co-learning about VR in this context may
306 foster a greater empathy and understanding between staff and patients. Staff hopes in future

307 research for greater involvement with and '*training*' in VR use were mentioned in discussion,
308 and will be considered below.

309 Practitioner-patient communication during procedures also emerged as a concern for the
310 nursing staff. For optimal distraction, pain and anxiety relief effects, the user ideally requires
311 deep immersion and minimal interruption from the outside world. Good nursing practice
312 involves keeping the patient informed and involved:

313 *'Normally when I'm doing a dressing, I'd explain what I'm doing, you know, explain*
314 *things on their legs or whatever, how their wound is, what it looks like'* (ns2).

315 Conflicting requirements placed nurses in a difficult position, caught between communication
316 as interruption and communication as involvement: *'I couldn't kind of work out what my role*
317 *was and what I should be doing... do you interrupt them when they're in that zone?'* (Ns2).
318 Despite a sense of '*inadequacy*' in uncertain circumstances, these experienced practitioners
319 navigated the situation well, opting to minimise their verbal interruptions to the most vital
320 information, such as imminent body position changes etc. Nurses discussed how they might
321 in future negotiate short breaks in the VR, when activities would temporarily cease to
322 facilitate communication.

323 **Discussion**

324 This study explored the acceptability, perceived effectiveness and usability of active and
325 passive VR scenarios in the clinical setting during inpatient dressing changes. Previous
326 evidence has demonstrated reduced pain in burn patients when using VR, but detailed patient
327 and staff perspectives have rarely been gathered. A recent mixed methods study set in a US
328 burns outpatient clinic collected quantitative data from staff and quantitative and qualitative
329 data from patients, which demonstrated satisfaction with and feasibility of the technology³³.
330 Our findings add to what is already known, by providing in-depth qualitative evidence from

331 both staff and patients which demonstrated that VR was acceptable, feasible and welcomed
332 by all participants when used during in-patient dressing changes. VR promoted distraction,
333 reduced perceived pain during dressings, enhanced wound care, and improved wellbeing.
334 Findings further suggested that immersive, active VR might be more useful in supporting
335 pain and anxiety relief than more passive versions of the technology. O

336 Previous authors have recommended research focusing on the extent to which fun and
337 presence contribute to effectiveness in VR interventions²². Our findings provide some insight
338 into these aspects, indicating that user-informed immersive scenarios (e.g. those with
339 increased presence and engagement) were particularly effective in distracting patients. They
340 also suggest that, as well as reducing the negative impacts of dressing change on pain,
341 anxiety and distress, immersive VR can create positive experiences of fun, challenge, hilarity
342 and laughter, 'lightening' the experience for all parties. This study compared VR to normal
343 care, which is minimal distraction, at best using a TV / video, but most often no pain relief
344 beyond pharmacological methods. It has been noted that, while other distraction techniques,
345 such as hypnosis, are effective, non-pharmacological interventions are rarely used in
346 practice³⁴. A majority of European Burn Centres have expressed dissatisfaction with their
347 current pain-management strategies for burns patients³⁵. This study contributes to a body of
348 evidence demonstrating the potential for VR in addressing procedural pain.

349 Several unanticipated effects of the VR are worthy of discussion.

350 First, increased patient tolerance offered the nurses greater scope to provide intensive wound
351 care, as reported elsewhere³², with positive potential for wound healing and recovery. This
352 was tolerated well during the procedure but may have contributed to some reports of lasting
353 pain afterwards. In addition, no matter how intensive the wound care, removing the VR also
354 removes the distraction and analgesic effects. There will probably never be a way of

355 eradicating pain completely; however these unanticipated (negative) effects on the pain
356 experience should be considered. It may mean the patient should be offered continued access
357 to the VR afterwards, with the immersive experience gradually reduced rather than suddenly
358 removed. It also suggests that VR and other forms of pain relief (such as analgesic
359 medication) may be used in a complementary way, with one introduced before the other is
360 withdrawn.

361 Second, communication during dressing changes is part of normal care, as a nurse informs
362 the patient about what he/she is doing, answers questions, including about wound progress,
363 and provides instruction to the patient, for example, about movements they need to assist
364 with. Nurses were unsure how to manage this part of their role and activities in the present
365 study, an issue which could be addressed more explicitly in future work. However, we
366 noticed that, despite their uncertainty, nurses navigated this challenge very successfully. As a
367 small team, the staff came to know their patients well and quickly developed an
368 understanding of how to tailor communication to meet patient need. Individual preferences
369 about communication could also be discussed with the patient, giving them an active role in
370 decisions about their wound care, which should also support effective pain management³⁶.

371 Third, outcomes suggested that the decision to avoid burdening staff inadvertently limited
372 their ability to support patients with its use. A recent mixed-methods study reported similar
373 findings from its qualitative interviews³³. Short-term research projects led by funded research
374 teams, in which researchers deliver the intervention, help demonstrate efficacy of an
375 intervention^{33,37}, and indeed, our work suggested benefits to both staff and patients. However,
376 more research needs to be done in which staff members are involved and empowered to
377 engage, understand, and independently operate the equipment and explain the technology to
378 patients. This helps ensure new treatments are properly costed and effectively integrated into
379 the clinical setting after the research is finished. Markus et al.³⁸ trialled VR as an adjunct to

380 physiotherapy and found that the costs to staff in terms of time, setting up, managing and
381 cleaning the equipment were so great, that they arguably outweighed the benefits to patients.
382 Morris et al.³⁷ explored VR for burns physiotherapy in South Africa, and found, in contrast,
383 that time spent managing the technology was not seen as problematic. Instead
384 physiotherapists felt freed to focus more on movement than pain using VR, potentially
385 benefitting patient recovery. This has resonance with our finding that nurses believed VR
386 allowed them to focus more intensively on wound care (rather than pain management). The
387 back-up systems, such as staff training, technical support, maintenance and cleaning of
388 equipment, which would allow an intervention such as VR to support existing care without
389 unduly burdening busy staff, simply aren't there³⁸. However, although systems are rarely in
390 place yet, once set up and established, VR systems could be applied without great time and
391 effort in routine clinical care of burn patients and others requiring dressing changes, such as
392 those undergoing reconstructive surgery²². Indeed, if hospitals make the investment in the
393 systems, there seems no reason why broader patient groups should not benefit, as suggested
394 by the patients and staff in the current study.

395 Our study had methodological strengths and limitations. Strengths included user involvement
396 in the development of the trialled active VR scenarios (for more detail, see Authors, 2018),
397 which proved very acceptable and apparently effective in reducing perceived pain and
398 anxiety. User involvement was recently recommended as a priority for burn rehabilitation
399 research²¹. The qualitative approach was a strength: interview data from both staff and
400 patients were very valuable in revealing unanticipated outcomes of this still relatively novel
401 intervention, including unexpected experiential aspects, and detailed insights into
402 implications of the technology for various stakeholders. This approach has been
403 recommended in intervention feasibility and development work²⁹; however it is relatively
404 unique in the field of VR research, which is dominated by quantitative approaches. Ford et

405 al.³³ gained some useful qualitative insights from patients but collected only quantitative data
406 from staff, which limited its depth.

407 Limitations include the very small sample, which was constrained by the single-centre
408 design, time limitations on funding use and clinical exclusion criteria. Future work should
409 adopt multi-centre designs, allow longer for recruitment, and consider ways to reduce
410 exclusions. For example, infection control concerns could be addressed by utilising
411 replaceable foam inserts for use with the VR kit. Patients with head or neck burns were also
412 excluded; however, one previous study found a way around this issue using arm-mounted VR
413 equipment. While less immersive than a headset, authors found that those using the VR
414 reported significantly lower pain than both passive distraction (watching a movie) and
415 standard care³⁹. This was similar to our findings indicating the superiority of active VR.
416 Having both head- and arm-mounted versions available would prevent excluding large
417 sections of the burn population from accessing effective VR-based pain relief.

418 Finally, previous authors³⁹ have recommended physiological measures of pain, and, in
419 keeping with its 'person-centred' approach²⁹, our study collected subjective perceptual data.
420 Our sense is that, if patients themselves believe their pain is reduced and more tolerable, this
421 should be sufficient recommendation. Indeed, pulse and BP ratings can increase under
422 conditions of excitement (such as when playing an immersive scenario) as well as pain, so are
423 open to misinterpretation. The patients' subjective experience and interpretation of their pain
424 may be the most useful measure in improving their experience and reducing short and long-
425 term impacts. Alternatively, if a more objective mode of pain assessment were required, one
426 promising approach could be treating pharmacological analgesia use as a proxy for pain. A
427 recent study found a 39% reduction in opioid requests under their immersive VR condition,
428 despite no significant differences in pain and anxiety ratings⁴⁰. Like ours, their intervention
429 was very positively evaluated, and 75% were willing to use it again. The finding of reduced

430 opiate analgesia during (and before and after) dressings due to lower pain perception⁴⁰ has
431 some support in our qualitative results. Reducing analgesia also reduces costs of care and
432 unwanted side effects. Side effects of opiates include respiratory depression, constipation,
433 sedation, nausea⁴¹⁻⁴³, and possibly even immunosuppression and infection⁴². Decreased use of
434 sedating, nauseating opiates may promote earlier mobilisation in recovery from burns²¹. VR
435 could have a role to play here, as suggested in physiotherapy studies^{37,38}, since it could enable
436 patients to focus on recovering movement, rather than on their pain.

437 This small study demonstrated the usability and acceptability of VR technology in a single
438 clinical setting, and the perceived effectiveness of active VR scenarios in managing the pain
439 and anxiety associated with dressing changes for five inpatients. Next steps would be to trial
440 on a multi-centre basis, using controlled approaches, as recommended by reviewers in the
441 area³⁴. Measures should also be taken to reduce exclusions, extend application of the
442 technology and recruit larger samples. Our experience suggests that future trials should
443 consider mixed methods because qualitative data help capture nuanced and unanticipated
444 outcomes. Staff preparation and involvement are important concerns, and teams should
445 consider the broader impact and analgesic potential of VR to address pain relief before,
446 during and after the procedure.

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