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BMJ Open

The experiences of stroke patients and rehabilitation professionals with upper limb rehabilitation robots: a qualitative systematic review protocol

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Manuscripts

1
2
3 23 Bagayam

4
5
6 24 Vellore – 632002

7
8
9 25 India

10
11
12 26 Email: siva82kb@cmcvellore.ac.in

13
14
15
16 27 Vimal Sriram

17
18 28 Head of Allied Health Professionals

19
20 29 University Hospitals Bristol and Weston NHS Foundation Trust

21
22
23 30 Trust HQ

24
25 31 Marlborough Hill

26
27
28 32 Bristol, BS1 3NU

29
30 33 Email: vimal.sriram@uhbw.nhs.uk

31
32
33
34 **Corresponding Author:**

35
36 35 Lenny Vasanthan

37
38 36 Reader in Physiotherapy

39
40 37 Christian Medical College, Vellore

41
42 38 Ida Scudder Road

43
44 39 Vellore 632 004

45
46 40 Tamil Nadu

47
48 41 India

49
50 42 Email: lennyv@cmcvellore.ac.in

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4 49 **The experiences of stroke patients and rehabilitation professionals with**
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6 50 **upper limb rehabilitation robots: a qualitative systematic review protocol**
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10 51 **ABSTRACT**
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13 52 **Introduction:** Despite their proven effectiveness for stroke rehabilitation, upper limb
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15 53 rehabilitation robots are underutilised by rehabilitation professionals. For robotic upper
16
17 54 limb rehabilitation in stroke to be successful, patients' experiences and those of the
18
19 55 rehabilitation professionals must be considered. Therefore, this review aims to synthesise
20
21 56 the available evidence on experiences of patients after a stroke with rehabilitation robots
22
23 57 for upper limb rehabilitation and the experiences of rehabilitation professionals with
24
25 58 rehabilitation robots for upper limb stroke rehabilitation.
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32 59 **Methods and Analysis:** Database search will include MEDLINE(Ovid), EMBASE(Elsevier),
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34 60 Cochrane CENTRAL, PsycINFO, Scopus, Web of Science, and CINAHL(EBSCOhost). Grey
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36 61 literature, from Open Grey, PsyArXiv, bioRxiv, medRxiv, and Google Scholar, will also be
37
38 62 searched. The inclusion criteria will be studies that include adult patients after a stroke
39
40 63 using rehabilitation robots for upper limb rehabilitation, either supervised by rehabilitation
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42 64 professional or by patients themselves, at any phase in their rehabilitation. Robotic upper
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44 65 limb rehabilitation provided by students, healthcare assistants, technicians, non-
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46 66 professional caregivers, family caregivers, volunteer caregivers, or other informal caregivers
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48 67 will be excluded. Articles published in English will be considered regardless of date of
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50 68 publication. Studies will be screened and critically appraised for methodological quality by
51
52 69 two independent reviewers. A standardised tool from JBI SUMARI for data extraction, the
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3 70 meta-aggregation approach for data synthesis, and the ConQual approach for confidence
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6 71 evaluation will be followed.
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9 72 **Ethics and Dissemination:** This systematic review is a secondary research project based on
10
11 73 previously published research, which does not require ethical approval or informed consent.
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14 74 It is anticipated that this systematic review will highlight the experiences of patients after a
15
16 75 stroke and perceived facilitators and barriers for rehabilitation professionals on this topic,
17
18 76 which will be disseminated through peer-reviewed publications and national and
19
20 77 international conferences.
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24
25 78 **Systematic review registration number:** PROSPERO-CRD42022321402
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29 79 **Keywords:** robotics; stroke; rehabilitation; experience; health personnel
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32 80 **Abstract word count:** 293
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3 81 **ARTICLE SUMMARY**
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7 82 **STRENGTHS AND LIMITATIONS OF THIS STUDY**
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- 10 83 1. This will be the only qualitative systematic review that specifically focuses on the
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12 experiences of adult patients after a stroke undergoing upper limb rehabilitation
13 84
14 with rehabilitation robots at any stage in their rehabilitation.
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20 87 2. This will be the first systematic review to focus on the experiences of rehabilitation
21
22 professionals providing upper limb rehabilitation for stroke patients using all types of
23 88
24 rehabilitation robots.
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30 91 3. This review will include only English-language publications due to limited financial
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32 resources, which will limit the review's comprehensiveness.
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93 INTRODUCTION

94 The use of rehabilitation robots has grown over the past few decades,[1] particularly for
95 upper limb stroke rehabilitation, and the evidence supporting their use is also
96 increasing.[2,3] Several rehabilitation robots are available to assess and rehabilitate stroke-
97 impaired upper limbs, including end-effectors,[4,5] (Figure 1 and Figure 2) exoskeletons,[6]
98 (Figure 3) and exosuits.[7] (Figure 4) They are comparable and may even be superior to
99 conventional rehabilitation in achieving various positive outcomes, such as reducing upper
100 limb motor impairment.[2] In addition, systematic reviews of rehabilitation robots in upper
101 limb stroke rehabilitation have demonstrated that they provide valid outcome
102 measurements of clinically meaningful body functions and structures of the ICF domain,
103 such as muscle viscoelasticity[8] and movement-related kinematic parameters.[9]
104 Rehabilitation robots are therefore increasingly being incorporated into rehabilitation
105 programs both as intervention devices and as tools for evaluating clinical outcomes.
106 Even though rehabilitation robots are effective in stroke rehabilitation,[1-3] few studies or
107 reviews compare the types of robots used, which may explain the varying results.[10,11]
108 Mehrholz et al., for example, reported that there is no difference between the types of
109 robots and the improvements in upper limb functional performance in their meta-analysis
110 of robot-assisted upper limb training in patients after a stroke.[10] In contrast, based on
111 their meta-analysis, Mogio et al. determined that exoskeleton robots are significantly
112 superior to end-effector robots in improving finger and hand motor function in patients
113 after a stroke.[11] It should be noted that the use of exosuit robots in rehabilitation is a
114 relatively new innovation in robotics and no comparison studies have been completed to
115 date.[7,12,13]

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3 116 Due to the variety of robots available that provide similar clinical outcomes, selecting an
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6 117 appropriate robotic intervention strategy for patients after a stroke by rehabilitation
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8 118 professionals may be complex and challenging.[10] Thus, the subjective experiences of
9
10 119 rehabilitation professionals with robots become crucial in the selection and use of
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13 120 rehabilitation robots in clinical practice. Despite rehabilitation robots being clinically
14
15 121 effective, the fact that rehabilitation professionals remain cautious when recommending
16
17 122 them in clinical practice makes it even more important to study their experiences with and
18
19 123 attitudes towards rehabilitation robots.[14,15] Literature also acknowledges this need,
20
21 124 pointing out that rehabilitation professionals' attitudes are as important as the benefits
22
23 125 derived from robots, if upper limb rehabilitation robots are to be successfully incorporated
24
25 126 into clinical practice and emphasises the need for a systematic approach to the adoption of
26
27 127 such robots in rehabilitation.[14,15] Therefore, it is necessary to systematically review,
28
29 128 document, and compile rehabilitation professionals' perspectives, experiences, and views
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31 129 on upper limb rehabilitation robots.
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38 130 Like rehabilitation professionals, the experiences of patients after a stroke, as the end-users
39
40 131 of rehabilitation robots, are also vital. The experiences of patients with rehabilitation robots
41
42 132 may differ from those of rehabilitation professionals, and therefore, these experiences
43
44 133 should be analysed and reported separately. After a stroke, patients tend to prioritise their
45
46 134 personal needs and participation in meaningful activities over that of impairment-focused
47
48 135 rehabilitation.[16] It is therefore imperative to conduct a comprehensive review of patient
49
50 136 experiences related to the use of rehabilitation robots, which may lead to an increase in the
51
52 137 acceptance of such devices, and their sustainable use as well as leading to more user-
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54 138 centred designs. Further, a comprehensive summary of patients' likes, dislikes, and
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3 139 preferences for specific upper limb rehabilitation robots is fundamental when outcomes
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6 140 among the types of robots are largely similar.[10]
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9 141 The only systematic review to date that aimed to meta-synthesise end-user perceptions of
10
11 142 robotics is in motor rehabilitation[17] and provides an early, generic description of the
12
13
14 143 patients', caregivers', and professionals' experiences with rehabilitation robots. In the
15
16 144 review by Laparidou et al. an overview of all types of motor rehabilitation using
17
18 145 rehabilitation robots for various clinical conditions (shoulder instability/rotator cuff injury,
19
20 146 spinal cord injury, stroke, brain injury, cerebral palsy, and unspecified clinical conditions) of
21
22
23 147 all ages (from five to 84 years of age) is provided.[17] This review's inclusion of participants
24
25
26 148 with varied clinical presentations offers valuable insight into their generalised experiences
27
28 149 with rehabilitation robots. However, as the review focuses on a broad clinical group, it fails
29
30
31 150 to provide a comprehensive focus and in-depth description of rehabilitation robots' use in
32
33
34 151 adult patients with stroke. Stroke upper limb rehabilitation robots for adults require
35
36 152 particular considerations because patients after a stroke have unique needs,[18]
37
38 153 abilities,[19] and patterns of functional recovery[20] that are distinct from those of other
39
40
41 154 patients, such as patients with spinal cord injury[21,22] or children with cerebral palsy.[23]
42
43 155 Thus, the experiences of patients with rehabilitation robots in stroke rehabilitation must be
44
45
46 156 given due consideration and fill the gap in the literature that so far has predominantly
47
48 157 looked at multiple clinical conditions without an in-depth focus on patients with stroke, in
49
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51 158 order to assist rehabilitation professionals' decision-making about robotics in this clinical
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53 159 area.
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57 160 A preliminary search of PROSPERO, MEDLINE, Cochrane Database of Systematic Reviews,
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59 161 and JBI Evidence Synthesis was conducted on 01 March 2022. This search did not identify
60

1
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3 162 any current or ongoing scoping or systematic reviews that focus on patients after a stroke or
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6 163 their rehabilitation professionals' experience with upper limb rehabilitation robots.
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8 164 Reinforcing the need for a qualitative systematic review to explore and establish the full
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11 165 range of experiences of patients and their rehabilitation professionals with upper limb
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13 166 rehabilitation robots in stroke rehabilitation.
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167 **METHODS AND ANALYSIS**

168 **Objective**

169 This review aims to collect and synthesise available evidence regarding the experiences of
170 patients after a stroke with rehabilitation robots for upper limb rehabilitation irrespective of
171 the ongoing involvement of rehabilitation professionals as well as the experiences of
172 rehabilitation professionals with rehabilitation robots for upper limb stroke rehabilitation.
173

173 **Review questions**

- 174 1. What are the experiences of patients after a stroke when undergoing rehabilitation
175 for stroke-related upper limb dysfunction using rehabilitation robots?
- 176 2. What are the rehabilitation professionals' experiences, perspectives, opinions, and
177 perceived facilitators and barriers regarding the use of rehabilitation robots for
178 upper limb rehabilitation among patients after a stroke?

179 **Eligibility criteria**

180 **Participants**

181 This review will consider studies that include adult patients (over the age of 18) after a
182 stroke using rehabilitation robots for upper limb rehabilitation, either supervised by

1
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3 183 rehabilitation professionals or by patients themselves, as part of self-administered robotic
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6 184 therapy at any phase of their rehabilitation.
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9 185 To clarify our inclusion criteria, we have used the following definitions:
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13 186 *Stroke* – a sudden loss of neurological function caused by haemorrhage or ischemia in the
14
15 187 brain parenchyma caused by a vascular event, with symptoms lasting more than 24 hours,
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17 188 which are not explainable by other causes.
18
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21 189 *Phases of rehabilitation* – time after stroke as classified by the Stroke Roundtable
22
23 Consortium;^[24] namely, the hyperacute phase (< 24 hours), the acute phase (2-7 days), the
24 190
25 early subacute phase (8-90 days), late subacute phase (91-180 days) and chronic phase
26 191
27 (>180 days).
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32 193 *Upper limb rehabilitation* – interventions aimed at enhancing the function of the upper limb
33
34 194 after considering the goals of patients after a stroke, which are identified following
35
36 195 evaluations of their functional abilities and level of activity.
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41 196 *Rehabilitation robots* – robots that have contact with a patient to provide physical
42
43 197 interaction driven by an actuation system and controlled by the robot alone or in a robot
44
45 198 and patient shared control to perform rehabilitation, assessment, compensation, or
46
47 199 alleviation.^[25] Rehabilitation robots may be fixed, mobile, or wearable devices used during
48
49 200 inpatient, outpatient, home-based, or community-based rehabilitation. These rehabilitation
50
51 201 robots may include mechanical setups such as end-effectors, exoskeletons, or exosuits.
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56 202 *End-effectors* – robots with a single point of connection to a patient's distal segment, with
57
58 203 joints that are neither matched to nor aligned with other joints of the patient, where the
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3 204 force generated by the robot's distal interface is transmitted to other joints of the patient in
4
5 205 accordance with the principles of close-kinematic chains.[26] (Figure 1 and Figure 2)
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9 206 *Exoskeletons* – robots with rigid anthropomorphic structures attached to the body at
10
11 207 multiple points through straps, cuffs, belts, or other attachments, ensuring the robotic joint
12
13 208 axes are aligned with the anatomical joints of the wearer's body.[26] (Figure 3)
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18 209 *Exosuits* – robots that use softer materials such as fabric instead of rigid anthropomorphic
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20 210 structures.[26] (Figure 4)
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24 211 *Upper limb robotic rehabilitation* – robots assisting or resisting movement in a single joint or
25
26 212 controlling the intersegmental coordination of the affected upper limb as well as providing
27
28 213 and enhancing repetitive task training and task-specific training to improve range of motion,
29
30 214 strength, motor learning, and motor control.[10,26] In addition to assessing, compensating
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32 215 for, or alleviating the effects of stroke-related upper limb impairment.
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37 216 Studies that report patients with more than one stroke, patients under 18, or patients with
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39 217 other known causes of upper limb impairment besides stroke will be excluded. Studies
40
41 218 reporting patients without upper limb motor dysfunction or having sensory impairments
42
43 219 alone or cognitive and perceptual impairments alone will be excluded. Hospital robots,
44
45 220 social robots, or care/assistive robots that assist patients after a stroke in their activities of
46
47 221 daily living without being connected to their upper limb or robotic interventions other than
48
49 222 rehabilitation robots, as previously described, will be excluded. Studies reporting upper limb
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51 223 rehabilitation using rehabilitation robots in body segments other than the affected upper
52
53 224 limb will be excluded. Likewise, studies reporting upper limb robotic interventions
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3 225 conducted concurrently with other robotic interventions for other body segments,
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6 226 presented as a whole and not sufficiently distinguished from one another, will be excluded.
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9 227 This review will include rehabilitation professionals who provide stroke upper limb
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11 228 rehabilitation using rehabilitation robots. The rehabilitation professionals may be experts in
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13
14 229 upper limb rehabilitation, such as physiatrists, physical therapists, occupational therapists,
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16 230 hand therapists, or rehabilitation nurses. Other professionals such as emergency physicians,
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19 231 geriatricians, neurologists, neurosurgeons, or other physicians involved only in the medical
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21 232 or surgical management of patients with stroke who do not provide active upper limb
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24 233 rehabilitation will be excluded. Similarly, rehabilitation engineers, robotic engineers,
25
26 234 biomedical engineers, orthotists, and other specialists who are typically not directly involved
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29 235 in physical rehabilitation or clinical care for stroke patients will also be excluded. Robotic
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31 236 upper limb rehabilitation provided by students, healthcare assistants, or technicians, who
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34 237 may not be competent to practice independently, will be excluded. Likewise, robotic upper
35
36 238 limb rehabilitation provided by non-professional caregivers, family caregivers, volunteer
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38
39 239 caregivers, or other informal caregivers will also be excluded.
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41
42 240 Phenomena of interest
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46 241 In this review, studies that describe the experiences of patients after a stroke and/or their
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48 242 rehabilitation professional with upper limb rehabilitation robots will be considered. Patients'
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51 243 experiences during or after the use of upper limb rehabilitation robots for stroke can be
52
53 244 positive or negative, describe complications/adverse events or any other experiences.
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56 245 Rehabilitation professionals' experiences may include facilitators and barriers, encounters,
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3 246 perspectives, or opinions associated with preparing for or providing upper limb

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6 247 rehabilitation in stroke using rehabilitation robots.

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9 248 **Context**

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13 249 The context will not be restricted in this review. This review will consider studies that

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15 250 present patients after a stroke or rehabilitation professionals' experiences of providing

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17 251 upper limb rehabilitation using rehabilitation robots in any clinical setting during any phase

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20 252 of stroke rehabilitation. These settings may include outpatient, inpatient, community-based,

21
22 253 or home-based intervention services or other therapeutic settings. This review is not

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25 254 restricted to geographical locations, funding mechanisms, healthcare facilities, or services.

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29 255 **Types of studies**

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32 256 This review will consider studies that focus on qualitative data, including, but not limited to,

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34 257 designs such as qualitative descriptive, phenomenology, grounded theory, ethnography, and

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37 258 action research. This review will also consider the qualitative results of mixed-method

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40 259 studies.

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43 260 **Methods**

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47 261 The proposed systematic review will be conducted in accordance with the JBI methodology

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49 262 for systematic reviews of qualitative evidence.[27] The review protocol is registered in

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51
52 263 PROSPERO (CRD42022321402).

264 **Search strategy**

265 The search strategy will aim to locate both published and unpublished studies. A three-step
266 search strategy will be utilised in this review. First, a pilot initial limited search of MEDLINE
267 (Ovid) and CINAHL (EBSCOhost) was undertaken to identify articles on the topic. The text
268 words contained in the titles and abstracts of relevant articles and the index terms used to
269 describe the articles were used to develop a full search strategy for MEDLINE (Ovid) (see
270 Appendix 1). The search strategy, including all identified keywords and index terms, will be
271 adapted for each included database and/or information source. The reference lists of all
272 included sources of evidence will be screened for additional studies.

273 Regardless of the publication date, articles published in English will be included to capture
274 all relevant literature comprehensively. In view of the limited resources available to
275 reviewers to translate literature from other languages, languages other than English will be
276 excluded in this review. The databases will include MEDLINE(Ovid), EMBASE(Elsevier),
277 Cochrane CENTRAL, PsycINFO, Scopus, Web of Science, and CINAHL(EBSCOhost). Grey
278 literature will also be searched through Open Grey, PsyArXiv, bioRxiv, medRxiv, and Google
279 Scholar.

280 **Study selection**

281 After the search, the citations will be collated and uploaded into EndNote X20 (Clarivate
282 Analytics, PA, USA), and duplicates will be removed. After piloting the eligibility criteria on a
283 sample of citations (between six and eight articles) to ensure consistency in application,[28]
284 two independent reviewers (MC and LV) will screen all titles and abstracts to determine if
285 they meet the review's inclusion criteria and any disagreements will be resolved by mutual

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3 286 agreement in discussion with the third reviewer (VS). Potentially relevant studies will be
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6 287 retrieved in full, and their citation details imported into the JBI System for the Unified
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8 288 Management, Assessment and Review of Information (JBI SUMARI) (JBI, Adelaide,
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10 289 Australia).[29] The full text of selected citations will be assessed in detail against the
11
12
13 290 inclusion criteria by two independent reviewers (MC and LV), and any disagreements will be
14
15 291 resolved in discussion with VS. The reasons for the exclusion of full-text papers that do not
16
17 292 meet the inclusion criteria will be recorded and reported. The results of the search and the
18
19 293 study inclusion process will be reported in full in the final systematic review and presented
20
21 294 using a Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) flow
22
23 295 diagram.[30]

296 **Assessment of methodological quality**

31
32 297 Eligible studies will be critically appraised by two independent reviewers for methodological
33
34 298 quality using the standard JBI Critical Appraisal Checklist for Qualitative Research.[31] Any
35
36 299 disagreements that arise between the reviewers will be resolved through discussion with
37
38 300 the third reviewer. The results of the critical appraisal will be reported in narrative form and
39
40 301 tables. Regardless of the results of their methodological quality, all studies will be included
41
42 302 in the data extraction and synthesis process to ensure that all experiences are captured
43
44 303 comprehensively, and no evidence is missed. All major quality issues of the included studies
45
46 304 will be presented and discussed in the final review report.

53 305 **Data extraction**

54
55
56 306 Data will be extracted from studies included in the review by two independent reviewers
57
58 307 using the standardised JBI data extraction tool in JBI SUMARI.[29] The data extracted will
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60

1
2
3 308 include specific details about the population, context, culture, geographical location, study
4
5 309 methods, and the phenomena of interest relevant to the review objectives, namely
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7
8 310 experiences of using upper limb rehabilitation robots by patients after a stroke and
9
10 311 rehabilitation professionals' experiences of providing stroke upper limb rehabilitation using
11
12 312 robots. The findings, and their illustrations, will be extracted verbatim and assigned a level
13
14 313 of credibility. Any disagreements that arise between the reviewers will be resolved through
15
16 314 discussion with the third reviewer. If necessary, missing or additional data will be requested
17
18 315 from the authors. Even after obtaining additional information from the authors, all missing
19
20 316 or unclear information that continues to exist will be treated in the review report as missing
21
22 317 data.
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29 318 **Data synthesis**

30
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32 319 Qualitative research findings where possible, will be pooled using JBI SUMARI with the
33
34 320 meta-aggregation approach.[32] This will involve the aggregation or synthesis of findings to
35
36 321 generate a set of statements representing that aggregation by assembling the findings and
37
38 322 categorising these findings based on similarity in meaning. These categories will then be
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40 323 subjected to a synthesis to produce a single comprehensive set of synthesised findings that
41
42 324 can be used as a basis for evidence-based practice. Where textual pooling is not possible,
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44 325 the findings will be presented in a narrative form.
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50 326 **Assessing confidence in the findings**

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54 327 The final synthesised findings will be graded according to the ConQual approach for
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56 328 establishing confidence in the output of qualitative research synthesis and presented in a
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58 329 Summary of Findings.[33] The Summary of Findings includes the major elements of the
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1
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3 330 review and details how the ConQual score is developed. The title, population, phenomena
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6 331 of interest, and context for the specific review will be included in the summary of findings.
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8 332 Each synthesised finding from the review will then be presented, along with the type of
9
10 333 research informing it, the score for dependability and credibility, and the overall ConQual
11
12
13 334 score.

16 335 **Patient and public involvement**

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19
20 336 Patients and members of the public were not involved in the planning of this protocol.
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22

23 337 **DISCUSSION**

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26 338 The main aim of this review is to describe the experiences of patients after a stroke and
27
28 339 rehabilitation professionals' experiences with upper limb rehabilitation robots. The results
29
30 340 from this review are expected to inform better understanding of the use of upper limb
31
32 341 rehabilitation robots, perceptions, opinions, facilitators, and barriers to their use. This
33
34 342 review will highlight current research and available evidence in this important and emerging
35
36 343 topic area in upper limb rehabilitation after a stroke. The findings from this review will be
37
38 344 published and disseminated in journals, conferences and social media, and it is anticipated
39
40 345 that the findings from this review will be useful for patients after a stroke, rehabilitation
41
42 346 professionals, commissioners of health and care services and developers of rehabilitation
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44 347 robots to inform better provision and ongoing care for patients after a stroke.
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3 351 **FIGURE LEGENDS:**
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7 352 **Figure 1** illustrates an example of upper limb training using an end-effector robot, H-man.
8

9 353 *Note: The person shown in the picture is not a patient and was taken with the participant's
10
11 354 knowledge and permission. Picture courtesy of Articares.
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15 355 **Figure 2** illustrates an example of upper limb training using an end-effector robot,
16
17 MO.TO.RE. *Note: The person shown in the picture is not a patient and was taken with the
18 356 participant's knowledge and permission. Picture courtesy of Humanware S.r.l.
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24 358 **Figure 3** illustrates an example of upper limb training using an exoskeleton robot,
25
26 359 ArmeoPower. *Note: The person shown in the picture is not a patient and was taken with
27
28 360 the participant's knowledge and permission. Picture courtesy of Hocoma.
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32 361 **Figure 4** illustrates an example of an upper limb exosuit robot described by Hoang et al.
33
34 362 being worn by a volunteer. *Note: The person shown in the picture is not a patient and was
35
36 363 taken with the participant's knowledge and permission. Picture courtesy of Dr Thanh Nho
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38 364 Do.
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43 365 **ABBREVIATIONS:**
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47 366 CINAHL: Cumulative Index of Nursing and Allied Health Literature
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49 367 PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
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51 368 PROSPERO: International Prospective Register of Systematic Reviews
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54 369 JBI SUMARI: JBI System for the Unified Management, Assessment and Review of
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56 370 Information
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3 371 **AUTHOR CONTRIBUTIONS:**
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7 372 MC was responsible for the conceptualisation and design of the study with critical inputs
8
9 373 from LV, VS, and SB. MC developed the search strategy and conducted the search with
10
11 374 critical input from LV, VS, and SB. The protocol was drafted by MC with important
12
13
14 375 intellectual input and revisions from LV, VS, and SB. All authors have read and given
15
16 376 approval for this version and agree to be accountable for all aspects of the work. MC is the
17
18
19 377 guarantor of the review.
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28 380 or not-for-profit sectors.
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32 381 **CONFLICT OF INTERESTS STATEMENT:**
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36 382 The authors declare that there are no competing interests or conflicting interests.
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39 383 **DATA STATEMENT:**
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43 384 There are currently no data associated with this protocol. However, this protocol is
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45 385 published in PROSPERO. Details of this citation are as follows
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49 386 Manigandan Chockalingam, Lenny Vasanthan T, Sivakumar Balasubramanian, Vimal Sriram.
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59 390 from: https://www.crd.york.ac.uk/prospéro/display_record.php?ID=CRD42022321402
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Figure 1 illustrates an example of upper limb training using an end-effector robot, H-man. *Note: The person shown in the picture is not a patient and was taken with the participant's knowledge and permission. Picture courtesy of Articares.

724x254mm (300 x 300 DPI)



Figure 2 illustrates an example of upper limb training using an end-effector robot, MO.TO.RE. *Note: The person shown in the picture is not a patient and was taken with the participant's knowledge and permission. Picture courtesy of Humanware S.r.l.

721x265mm (300 x 300 DPI)



Figure 3 illustrates an example of upper limb training using an exoskeleton robot, ArmeoPower. *Note: The person shown in the picture is not a patient and was taken with the participant's knowledge and permission. Picture courtesy of Hocoma.

718x239mm (300 x 300 DPI)

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Figure 4 illustrates an example of an upper limb exosuit robot described by Hoang et al. being worn by a volunteer. *Note: The person shown in the picture is not a patient and was taken with the participant's knowledge and permission. Picture courtesy of Dr Thanh Nho Do.

618x314mm (300 x 300 DPI)

Ovid MEDLINE(R) ALL <1946 to May 20, 2022>

1 exp Psychiatrists/ or exp Health Personnel/ or exp Allied Health Personnel/ or exp Physicians/
 2 or exp Primary Health Care/ or exp Nurses/ or exp Family Nurse Practitioners/ or exp Nurse
 3 Practitioners/ or exp Physical Therapists/ or exp Occupational Therapists/ or health personnel.mp. or
 4 healthcare professional*.mp. or health-care professional*.mp. or health care professional*.mp. or
 5 allied health professional*.mp. or doctor*.mp. or physician*.mp. or geriatric*.mp. or rescriber*.mp.
 6 or primary healthcare.mp. or paramedic*.mp. or family nurse.mp. or nurse.mp. or community
 7 nurse.mp. or physio*.mp. or physiotherapist.mp. or physio therapist.mp. or physical therapist.mp. or
 8 hand therapist.mp. or self treatment.mp. or (Caregiver support regime therapy or Carer).mp. or
 9 Caregivers/ or (health care professional or health care professionals or health care provider or health
 10 care providers or healthcare provider or healthcare providers or healthcare worker or healthcare
 11 workers or personnel, health or professional, health care or provider, health care or provider,
 12 healthcare).mp. (Records Retrieved – 7196481)

2 exp "Attitude of Health Personnel"/ or exp Attitude/ or exp Occupational Stress/ or exp
 3 "Delivery of Health Care"/ or exp Qualitative Research/ or experience*.mp. or feel*.mp. or
 4 encounter*.mp. or perception*.mp. or opinion*.mp. (Records Retrieved – 3027183)

5 1 and 2 (Records Retrieved – 1094496)

6 exp "Quality of Health Care"/ or exp Patient Satisfaction/ or exp Patient Compliance/ or exp
 7 Compliance/ or exp "Patient Acceptance of Health Care"/ or exp "Treatment Adherence and
 8 Compliance"/ or exp Patient Dropouts/ or exp Treatment Refusal/ or exp Patient Participation/ or
 9 exp Psychological Distress/ or exp Health Behavior/ or exp "Quality of Life"/ or exp Attitude/ or exp
 10 Qualitative Research/ or patient satisfaction.mp. or patient acceptance.mp. or patient dropout*.mp.
 11 or patient participation.mp. or treatment refus*.mp. or experience*.mp. or feel*.mp. or
 12 encounter*.mp. or perception*.mp. or opinion*.mp. (Records Retrieved – 9171170)

13 3 or 4 (Records Retrieved – 9292409)

14 exp cerebrovascular disorders/ or exp basal ganglia cerebrovascular disease/ or exp brain
 15 ischemia/ or exp carotid artery diseases/ or exp cerebral small vessel diseases/ or exp intracranial
 16 arterial diseases/ or exp "intracranial embolism and thrombosis"/ or exp intracranial hemorrhages/
 17 or stroke/ or exp brain infarction/ or stroke, lacunar/ or vasospasm, intracranial/ or vertebral artery
 18 dissection/ or brain injuries/ or brain injury, chronic/ or (stroke* or poststroke or apoplex* or
 19 cerebral vasc* or brain vasc* or cerebrovasc* or cva* or SAH).mp. or ((brain or cerebr* or cerebell*
 20 or vertebrobasil* or hemispher* or intracran* or intracerebral or infratentorial or supratentorial or
 21 middle cerebral artery or MCA* or anterior circulation or posterior circulation or basilar artery or
 22 vertebral artery or space-occupying) adj5 (isch?emi* or infarct* or thrombo* or emboli* or occlus*
 23 or hypoxi*).mp. or ((brain* or cerebr* or cerebell* or intracerebral or intracran* or parenchymal or
 24 intraparenchymal or intraventricular or infratentorial or supratentorial or basal gangli* or putaminal
 25 or putamen or posterior fossa or hemispher* or subarachnoid) adj5 (h?emorrhag* or h?ematoma*
 26 or bleed*).mp. or hemiplegia/ or exp paresis/ or (hemipleg* or hemipar* or paresis or paretic or
 27 brain injur*).mp. (Records Retrieved – 805510)

28 exp upper extremity/ or (upper limb* or upper extremit* or arm or arms or shoulder or
 29 shoulders or hand or hands or axilla* or elbow* or forearm* or finger* or wrist*).mp. (Records
 30 Retrieved – 1087124)

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3 8 robotics/ or automation/ or orthotic devices/ or "equipment and supplies"/ or self-help
4 devices/ or therapy, computer-assisted/ or man-machine systems/ or (robot* or orthos* or orthotic
5 or automat* or computer aided or computer assisted or device*).mp. or (electromechanical or
6 electro-mechanical or mechanical or mechanised or mechanized or driven).mp. or exercise
7 movement techniques/ or exercise/ or exercise therapy/ or muscle stretching techniques/ or motion
8 therapy, continuous passive/ or ((continuous passive or cpm) adj3 therap*).mp. or (assist* adj5
9 (train* or aid* or rehabilitat* or re-educat*)).mp. (Records Retrieved – 2054580)

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S1 Table: Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Systematic Reviews 2015 4:1

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
ADMINISTRATIVE INFORMATION					
Title					
Identification	1a	Identify the report as a protocol of a systematic review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	4, 50
Update	1b	If the protocol is for an update of a previous systematic review, identify as such	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A.
Registration	2	If registered, provide the name of the registry (e.g., PROSPERO) and registration number in the Abstract	<input checked="" type="checkbox"/>	<input type="checkbox"/>	78, 262-263, 384-390
Authors					
Contact	3a	Provide name, institutional affiliation, and e-mail address of all protocol authors; provide physical mailing address of corresponding author	<input checked="" type="checkbox"/>	<input type="checkbox"/>	5-42
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	371-377
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
Support					
Sources	5a	Indicate sources of financial or other support for the review	<input type="checkbox"/>	<input checked="" type="checkbox"/>	378-380
Sponsor	5b	Provide name for the review funder and/or sponsor	<input type="checkbox"/>	<input checked="" type="checkbox"/>	378-380
Role of sponsor/funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol	<input type="checkbox"/>	<input checked="" type="checkbox"/>	378-380
INTRODUCTION					
Rationale	6	Describe the rationale for the review in the context of what is already known	<input checked="" type="checkbox"/>	<input type="checkbox"/>	106-166

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	168 -172
METHODS					
Eligibility criteria	8	Specify the study characteristics (e.g., PICO, study design, setting, time frame) and report characteristics (e.g., years considered, language, publication status) to be used as criteria for eligibility for the review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	179- 259
Information sources	9	Describe all intended information sources (e.g., electronic databases, contact with study authors, trial registers, or other grey literature sources) with planned dates of coverage	<input checked="" type="checkbox"/>	<input type="checkbox"/>	273-279
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	<input checked="" type="checkbox"/>	<input type="checkbox"/>	264-279 and Appendix 1
STUDY RECORDS					
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	280-334
Selection process	11b	State the process that will be used for selecting studies (e.g., two independent reviewers) through each phase of the review (i.e., screening, eligibility, and inclusion in meta-analysis)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	280-295
Data collection process	11c	Describe planned method of extracting data from reports (e.g., piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators	<input checked="" type="checkbox"/>	<input type="checkbox"/>	305-317
Data items	12	List and define all variables for which data will be sought (e.g., PICO items, funding sources), any pre-planned data assumptions and simplifications	<input type="checkbox"/>	<input checked="" type="checkbox"/>	305-317
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
		prioritization of main and additional outcomes, with rationale			
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis	<input checked="" type="checkbox"/>	<input type="checkbox"/>	296-304
DATA					
Synthesis	15a	Describe criteria under which study data will be quantitatively synthesized	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data, and methods of combining data from studies, including any planned exploration of consistency (e.g., I^2 , Kendall's tau)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
	15c	Describe any proposed additional analyses (e.g., sensitivity or subgroup analyses, meta-regression)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned	<input checked="" type="checkbox"/>	<input type="checkbox"/>	318-325
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (e.g., publication bias across studies, selective reporting within studies)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (e.g., GRADE)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	326-334

BMJ Open

The experiences of stroke patients and rehabilitation professionals with upper limb rehabilitation robots: a qualitative systematic review protocol

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TITLE PAGE**1**
2 Title of the article:

3 The experiences of stroke patients and rehabilitation professionals with upper limb
4 rehabilitation robots: a qualitative systematic review protocol

5 Authors

6 Manigandan Chockalingam

7 Lecturer in Occupational Therapy

8 School of Health Sciences

9 R.No. 213 Moyola Building

10 National University of Ireland Galway

11 Galway

12 Ireland

13 Email: Manigandan.Chockalingam@nuigalway.ie; manigandan93@yahoo.com

14 Lenny Vasanthan

15 Reader in Physiotherapy

16 Christian Medical College, Vellore

17 Vellore – 632004

18 India

19 Email: lennyv@cmcvellore.ac.in

20 Sivakumar Balasubramanian

21 Professor and Head of Bioengineering

22 Christian Medical College

1
2
3 23 Bagayam
4
5
6 24 Vellore – 632002
7
8
9 25 India
10
11
12 26 Email: siva82kb@cmcvellore.ac.in
13
14
15
16 27 Vimal Sriram
17
18 28 Head of Allied Health Professionals
19
20 29 University Hospitals Bristol and Weston NHS Foundation Trust
21
22
23 30 Trust HQ
24
25 31 Marlborough Hill
26
27
28 32 Bristol, BS1 3NU
29
30 33 Email: vimal.sriram@uhbw.nhs.uk
31
32
33
34 **Corresponding Author:**
35
36 35 Lenny Vasanthan
37
38 36 Reader in Physiotherapy
39
40 37 Christian Medical College, Vellore
41
42 38 Ida Scudder Road
43
44 39 Vellore 632 004
45
46 40 Tamil Nadu
47
48 41 India
49
50 42 Email: lennyv@cmcvellore.ac.in
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3 49 **The experiences of stroke patients and rehabilitation professionals with**
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6 50 **upper limb rehabilitation robots: a qualitative systematic review protocol**
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10 51 **ABSTRACT**
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12

13 52 **Introduction:** Emerging evidence suggests that robotic devices for upper limb rehabilitation
14
15 53 after a stroke may improve upper limb function. For robotic upper limb rehabilitation in
16
17 54 stroke to be successful, patients' experiences and those of the rehabilitation professionals
18
19 55 must be considered. Therefore, this review aims to synthesise the available evidence on
20
21 56 experiences of patients after a stroke with rehabilitation robots for upper limb rehabilitation
22
23 57 and the experiences of rehabilitation professionals with rehabilitation robots for upper limb
24
25 58 stroke rehabilitation.
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32 59 **Methods and Analysis:** Database search will include MEDLINE(Ovid), EMBASE(Elsevier),
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34 60 Cochrane CENTRAL, PsycINFO, Scopus, Web of Science, IEEE and CINAHL(EBSCOhost). Grey
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36 61 literature from Open Grey, PsyArXiv, bioRxiv, medRxiv, and Google Scholar, will also be
37
38 62 searched. Qualitative studies or results from mixed-method studies that include adult
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40 63 patients after a stroke who use upper limb rehabilitation robots, either supervised by
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42 64 rehabilitation professionals or by patients themselves, at any stage of their rehabilitation
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44 65 and/or stroke professionals who use upper limb rehabilitation robots will be included.
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46 66 Robotic upper limb rehabilitation provided by students, healthcare assistants, technicians,
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48 67 non-professional caregivers, family caregivers, volunteer caregivers, or other informal
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50 68 caregivers will be excluded. Articles published in English will be considered regardless of
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52 69 date of publication. Studies will be screened and critically appraised for methodological
53
54 70 quality by two independent reviewers. A standardised tool from JBI SUMARI for data
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2
3 71 extraction, the meta-aggregation approach for data synthesis, and the ConQual approach
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5 72 for confidence evaluation will be followed.
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9 73 **Ethics and Dissemination:** As this systematic review is based on previously published
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11 74 research, no informed consent or ethical approval is required. It is anticipated that this
12
13 75 systematic review will highlight the experiences of patients after a stroke and perceived
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15 76 facilitators and barriers for rehabilitation professionals on this topic, which will be
16
17 77 disseminated through peer-reviewed publications and national and international
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19 78 conferences.
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25 79 **Systematic review registration number:** PROSPERO-CRD42022321402
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28 80 **Keywords:** robotics; stroke; rehabilitation; experience; health personnel
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32 81 **Abstract word count:** 297
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3 **82 ARTICLE SUMMARY**
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7 **83 STRENGTHS AND LIMITATIONS OF THIS STUDY**
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- 10 84 1. This review will include literature from inter-disciplinary databases to maximise
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13 85 diversity of data.
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15 86 2. Inclusion of grey literature in this review will provide comprehensive information of
16
17
18 87 experiences in the use of upper limb rehabilitation robots that are not commercially
19
20 88 available.
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23 89 3. Use of ConQual approach will ensure confidence in the synthesised findings of this
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25 90 review.
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28 91 4. This review will include only English-language publications due to limited financial
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30 92 resources, which will limit the reviews comprehensiveness.
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93 INTRODUCTION

94 The use of rehabilitation robots has grown over the past few decades,[1] particularly for
95 upper limb stroke rehabilitation, and the evidence supporting their use is also
96 increasing.[2,3] Several rehabilitation robots are available to assess and augment
97 rehabilitation of stroke-impaired upper limbs under direct or remote supervision, including
98 end-effectors,[4,5] (Figure 1 and Figure 2) exoskeletons,[6] (Figure 3) and exosuits.[7]
99 (Figure 4) The use of rehabilitation robots produces comparable results,[8] and in some
100 cases, such as when used by individuals with upper extremity hemiplegia, who have limited
101 chances of spontaneous recovery after stroke, they could produce better results than those
102 achieved by other routine therapy methods.[2,3] In addition, systematic reviews of
103 rehabilitation robots in upper limb stroke rehabilitation have demonstrated that they
104 provide valid outcome measurements of clinically meaningful body functions and structures
105 of the ICF domain, such as muscle viscoelasticity[9] and movement-related kinematic
106 parameters.[10] For these reasons, rehabilitation robots are receiving increasing attention
107 in rehabilitation programs as intervention devices and tools for evaluating clinical outcomes.
108 Although rehabilitation robots have not been extensively examined for their adoption in
109 routine care, the increasing number of robots being commercialised over the past decade
110 and the increased number of robotic literature suggests a slow and steady adoption.[11]
111 There is some emerging evidence that rehabilitation robots may improve upper limb
112 function after a stroke.[1-3] Studies have compared different types of robots in concluding
113 effectiveness of upper limb function,[8,12] which may explain the varying results between
114 studies that support or negate the effectiveness of upper limb robotic rehabilitation.
115 Mehrholz et al., for example, reported that there is no difference between the types of

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3 116 robots and the improvements in upper limb functional performance in their meta-analysis
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6 117 of robot-assisted upper limb training in patients after a stroke.[8] In contrast, the meta-
7
8 118 analysis by Mogio et al. found that exoskeleton robots are significantly superior to end-
9
10 119 effector robots in improving finger and hand motor function in patients after a stroke.[12] It
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13 120 should be noted that the use of Exosuits in rehabilitation is a relatively new approach in
14
15 121 rehabilitation robotics, and no comparison studies have been completed to date.[7,13,14]
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19 122 Due to the variety of robots available that provide similar clinical outcomes, selecting an
20
21 123 appropriate robotic intervention strategy for patients after a stroke by rehabilitation
22
23 124 professionals may be complex and challenging.[8] Thus, the subjective experiences of
24
25 125 rehabilitation professionals with robots become crucial in the selection and use of
26
27 126 rehabilitation robots in clinical practice. Despite rehabilitation robots being clinically
28
29 127 effective, the fact that rehabilitation professionals remain cautious when recommending
30
31 128 them in clinical practice makes it even more important to study their experiences with and
32
33 129 attitudes towards rehabilitation robots.[15,16] The literature also acknowledges this need,
34
35 130 pointing out that rehabilitation professionals' attitudes are as important as the benefits
36
37 131 derived from robots.[15,16] If upper limb rehabilitation robots are to be successfully
38
39 132 incorporated into clinical practice there is a need for a systematic approach to the adoption
40
41 133 of such robots in rehabilitation.[15,16] Therefore, it is necessary to systematically review,
42
43 134 document, and compile rehabilitation professionals' perspectives, experiences, and views
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45 135 on upper limb rehabilitation robots.
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54 136 Renaud and Van Biljon assert that a person's adoption of technology begins when they
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56 137 become aware of it and ends when they accept and fully utilise it.[17] The perceptions,
57
58 138 perspectives, satisfaction and other experiences of an end user play a significant role in
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3 139 determining whether that end user will successfully adopt the technology and whether the
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6 140 technology will continue to be used or discontinued.[18] Thus, the experiences of patients
7
8 141 who use rehabilitation robots after a stroke are as significant as those of rehabilitation
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10 142 professionals. The experiences of patients with rehabilitation robots may differ from those
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12
13 143 of rehabilitation professionals, and therefore, these experiences should be analysed and
14
15 144 reported separately. After a stroke, patients tend to prioritise their personal needs and
16
17
18 145 participation in meaningful activities over that of impairment-focused rehabilitation.[19] It is
19
20 146 therefore imperative to conduct a comprehensive review of patient experiences related to
21
22
23 147 the use of rehabilitation robots, which may lead to an increase in the acceptance and
24
25 148 sustained use of these devices by informing improved user-centred designs. Further, a
26
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28 149 comprehensive summary of patients' likes, dislikes, and preferences for specific upper limb
29
30 150 rehabilitation robots is fundamental when outcomes among the types of robots are largely
31
32
33 151 similar.[8]

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36 152 The only systematic review to date that aimed to meta-synthesise end-user perceptions of
37
38 153 robotics is in motor rehabilitation[20] and provides an early, generic description of the
39
40
41 154 patients', caregivers', and professionals' experiences with rehabilitation robots. In the
42
43
44 155 review by Laparidou et al., an overview of all types of motor rehabilitation using
45
46 156 rehabilitation robots for various clinical conditions (shoulder instability/rotator cuff injury,
47
48 157 spinal cord injury, stroke, brain injury, cerebral palsy, and unspecified clinical conditions) of
49
50
51 158 all ages (from five to 84 years of age) is provided.[20] This review's inclusion of participants
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53 159 with varied clinical presentations offers valuable insight into their generalised experiences
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56 160 with rehabilitation robots. However, as the review focuses on a broad clinical group, it fails
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58 161 to provide a comprehensive focus and in-depth description of rehabilitation robots' use in
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3 162 adult patients with stroke. Stroke upper limb rehabilitation robots for adults require
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5 163 particular considerations due to their unique needs,[21] abilities,[22] and patterns of
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7 164 functional recovery[23] that are distinct from those of other patient populations, such as
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9 165 spinal cord injury[24,25] or children with cerebral palsy.[26] This work addresses the lack of
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11 166 an in-depth focus on patients with stroke to fill the gap in the literature that so far has
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13 167 predominantly looked at multiple clinical conditions.

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19 168 A preliminary search of PROSPERO, MEDLINE, Cochrane Database of Systematic Reviews,
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21 169 and JBI Evidence Synthesis was conducted on 01 March 2022. During the search, no scoping
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23 170 or systematic reviews were identified that focused on the experiences of the use of upper
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25 171 limb rehabilitation robots by stroke patients or their rehabilitation professionals, indicating
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27 172 the necessity for a qualitative systematic review to further explore this.

31 32 173 **METHODS AND ANALYSIS**

33 34 35 174 **Objective**

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38 175 This review aims to collect and synthesise available evidence regarding the experiences of
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40 176 patients after a stroke using robots for upper limb rehabilitation irrespective of the ongoing
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42 177 involvement of rehabilitation professionals and the experiences of rehabilitation
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44 178 professionals using robots for upper limb stroke rehabilitation.

45 46 47 48 49 179 **Review questions**

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53 180 1. What are the experiences of patients after a stroke when undergoing rehabilitation
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55 181 for upper limb dysfunction using rehabilitation robots?
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3 182 2. What are the rehabilitation professionals' experiences, perspectives, opinions, and
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6 183 perceived facilitators and barriers regarding the use of rehabilitation robots for
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8 184 upper limb stroke rehabilitation?
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12 185 **Eligibility criteria**

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14 186 **Participants**

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18 187 This review will consider studies that include adult patients (over the age of 18) after a
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20 188 stroke using rehabilitation robots for upper limb rehabilitation, either supervised by
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23 189 rehabilitation professionals or by patients themselves, as part of self-administered robotic
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25 190 therapy at any phase of their rehabilitation.
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29 191 To clarify our inclusion criteria, we have used the following definitions:
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32 192 *Stroke* – a sudden loss of neurological function caused by haemorrhage or ischemia in the
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35 193 brain parenchyma caused by a vascular event, with symptoms lasting more than 24 hours,
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37 194 which are not explainable by other causes.
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41 195 *Phases of rehabilitation* – time after stroke as classified by the Stroke Roundtable

42
43 196 Consortium;^[27] namely, the hyperacute phase (< 24 hours), the acute phase (2-7 days), the
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46 197 early subacute phase (8-90 days), late subacute phase (91-180 days) and chronic phase
47
48 198 (>180 days).
49

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52 199 *Upper limb rehabilitation* – interventions aimed at enhancing the function of the upper limb
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54 200 after considering the goals of patients after a stroke, which are identified following
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57 201 evaluations of their functional abilities and level of activity.
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3 202 *Rehabilitation robots* – robots that have contact with a patient to provide physical
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6 203 interaction driven by an actuation system and controlled by the robot alone or in a robot
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8 204 and patient shared control to perform rehabilitation, assessment, compensation, or
9
10 205 alleviation.[28] Rehabilitation robots may be fixed, mobile, or wearable devices used during
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12 206 inpatient, outpatient, home-based, or community-based rehabilitation. These rehabilitation
13
14 207 robots may take the forms of end-effectors, exoskeletons, or exosuits.

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19 208 *End-effectors* – robots with a single point of connection to a patient's distal segment, with
20
21 209 joints that are neither matched to nor aligned with other joints of the patient, where the
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23 210 force generated by the robot's distal interface is transmitted to other joints of the patient in
24
25 211 accordance with the principles of close-kinematic chains.[29] (Figure 1 and Figure 2)

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30 212 *Exoskeletons* – robots with rigid anthropomorphic structures attached to the body at
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32 213 multiple points through straps, cuffs, belts, or other attachments, ensuring the robotic joint
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34 214 axes are aligned with the anatomical joints of the wearer's body.[29] (Figure 3)

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38 215 *Exosuits* – robots that use softer materials such as fabric instead of rigid anthropomorphic
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40 216 structures.[29] (Figure 4)

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44 217 *Upper limb robotic rehabilitation* – robots assisting or resisting movement in a single joint or
45
46 218 controlling the intersegmental coordination of the affected upper limb as well as providing
47
48 219 and enhancing repetitive task training and task-specific training to improve range of motion,
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50 220 strength, motor learning, and motor control.[8,29] In addition to assessing, compensating
51
52 221 for, or alleviating the effects of stroke-related upper limb impairment.

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3 222 Studies that report patients with more than one stroke, patients under 18, or patients with
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5 223 other known causes of upper limb impairment besides stroke will be excluded. Studies
6
7 224 reporting patients without upper limb motor dysfunction or having sensory impairments
8
9 225 alone or cognitive and perceptual impairments alone will be excluded. Hospital robots,
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11 226 social robots, or care/assistive robots that assist patients after a stroke in their activities of
12
13 227 daily living without being connected to their upper limb or robotic interventions other than
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15 228 rehabilitation robots, as previously described, will be excluded. Studies reporting upper limb
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17 229 rehabilitation using rehabilitation robots in body segments other than the affected upper
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19 230 limb will be excluded. Likewise, studies reporting upper limb robotic interventions
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21 231 conducted concurrently with other robotic interventions for other body segments,
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23 232 presented as a whole and not sufficiently distinguished from one another, will be excluded.
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31 233 This review will include professionals who provide stroke upper limb rehabilitation using
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33 234 rehabilitation robots. The rehabilitation professionals may be experts in upper limb
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35 235 rehabilitation, such as physiatrists, physical therapists, occupational therapists, hand
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37 236 therapists, or rehabilitation nurses. Other professionals such as emergency physicians,
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39 237 geriatricians, neurologists, neurosurgeons, or other physicians involved only in the medical
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41 238 or surgical management of patients with stroke who do not provide active upper limb
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43 239 rehabilitation will be excluded. Similarly, rehabilitation engineers, robotic engineers,
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45 240 biomedical engineers, orthotists, and other specialists who are typically not directly involved
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47 241 in physical rehabilitation or clinical care for stroke patients will also be excluded. Robotic
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49 242 upper limb rehabilitation provided by students, healthcare assistants, or technicians, who
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51 243 may not be competent to practice independently, will be excluded. Likewise, robotic upper
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3 244 limb rehabilitation provided by non-professional caregivers, family caregivers, volunteer
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6 245 caregivers, or other informal caregivers will also be excluded.
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9 246 Phenomena of interest
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13 247 In this review, studies that describe the experiences of patients after a stroke and/or their
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15 248 rehabilitation professional with upper limb rehabilitation robots will be considered. Patients'
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17 249 experiences during or after the use of upper limb rehabilitation robots for stroke can be
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19
20 250 positive or negative, describe complications/adverse events or any other experiences.
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22 251 Rehabilitation professionals' experiences may include facilitators and barriers, encounters,
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24 252 perspectives, or opinions associated with preparing for or providing upper limb
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27 253 rehabilitation in stroke using rehabilitation robots.
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31 254 Context
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35 255 The context will not be restricted in this review. This review will consider studies that
36
37 256 present patients after a stroke or rehabilitation professionals' experiences of providing
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39 257 upper limb rehabilitation using rehabilitation robots in any clinical setting during any phase
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42 258 of stroke rehabilitation. These settings may include outpatient, inpatient, community-based,
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44 259 or home-based intervention services or other therapeutic settings. This review is not
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47 260 restricted to geographical locations, funding mechanisms, healthcare facilities, or services.
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50 261 Types of studies
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54 262 This review will consider studies that focus on qualitative data, including, but not limited to,
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56 263 designs such as qualitative descriptive, phenomenology, grounded theory, ethnography, and
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3 264 action research. This review will also consider the qualitative results of mixed-method
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6 265 studies.

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9 266 **Methods**

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13 267 The proposed systematic review will be conducted in accordance with the JBI methodology
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15 268 for systematic reviews of qualitative evidence.[30] The review will commence in October
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18 269 2022 and end in September 2023. The review protocol is registered in PROSPERO
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20 270 (CRD42022321402).

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24 271 **Search strategy**

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27 272 The search strategy will aim to locate both published and unpublished studies. A three-step
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30 273 search strategy will be utilised in this review. First, a pilot initial limited search of MEDLINE
31
32 274 (Ovid) and CINAHL (EBSCOhost) was undertaken to identify articles on the topic. The text
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35 275 words contained in the titles and abstracts of relevant articles and the index terms (such as
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37 276 MeSH terms) used to describe the articles were used to develop a full search strategy for
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40 277 MEDLINE (Ovid) (see Appendix 1). The search strategy, including all identified keywords and
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42 278 index terms, will be adapted for each included database and/or information source. The
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45 279 reference lists of all included sources of evidence will be screened for additional studies.

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48 280 Regardless of the publication date, articles published in English will be included to capture
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51 281 all relevant literature comprehensively. In view of the limited resources available to
52
53 282 reviewers to translate literature from other languages, languages other than English will be
54
55 283 excluded in this review. The databases will include MEDLINE(Ovid), EMBASE(Elsevier),
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58 284 Cochrane CENTRAL, PsycINFO, Scopus, Web of Science, IEEE and CINAHL(EBSCOhost). Grey
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3 285 literature will also be searched through Open Grey, PsyArXiv, bioRxiv, medRxiv, and Google
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6 286 Scholar.
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9 287 **Study selection**
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12 288 After the search, the citations will be collated and uploaded into EndNote X20 (Clarivate
13
14 289 Analytics, PA, USA), and duplicates will be removed. After piloting the eligibility criteria on a
15
16 290 sample of citations (between six and eight articles) to ensure consistency in application,[31]
17
18 291 two independent reviewers (MC and LV) will screen all titles and abstracts to determine if
19
20 292 they meet the review's inclusion criteria and any disagreements will be resolved by mutual
21
22 293 agreement in discussion with the third reviewer (VS/SB). Potentially relevant studies will be
23
24 294 retrieved in full, and their citation details imported into the JBI System for the Unified
25
26 295 Management, Assessment and Review of Information (JBI SUMARI) (JBI, Adelaide,
27
28 296 Australia).[32] The full text of selected citations will be assessed in detail against the
29
30 297 inclusion criteria by two independent reviewers (MC and LV), and any disagreements will be
31
32 298 resolved in discussion with VS/SB. The reasons for the exclusion of full-text papers that do
33
34 299 not meet the inclusion criteria will be recorded and reported. The results of the search and
35
36 300 the study inclusion process will be reported in full in the final systematic review and
37
38 301 presented using a Preferred Reporting Items for Systematic Reviews and Meta-analyses
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47 302 (PRISMA) flow diagram.[33]
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49

50 303 **Assessment of methodological quality**
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54 304 Eligible studies will be critically appraised by two independent reviewers for methodological
55
56 305 quality using the standard JBI Critical Appraisal Checklist for Qualitative Research.[34] Any
57
58 306 disagreements that arise between the reviewers will be resolved through discussion with
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3 307 the third reviewer. The results of the critical appraisal will be reported in narrative form and
4
5 308 tables. Regardless of the results of their methodological quality, all studies will be included
6
7
8 309 in the data extraction and synthesis process to ensure that all experiences are captured
9
10 310 comprehensively, and no evidence is missed. All major quality issues of the included studies
11
12
13 311 will be presented and discussed in the final review report.
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16 312 **Data extraction**

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20 313 Data will be extracted from studies included in the review by two independent reviewers
21
22 314 using the standardised JBI data extraction tool in JBI SUMARI.[32] The data extracted will
23
24 315 include specific details about the population, context, culture, geographical location, study
25
26 316 methods, and the phenomena of interest relevant to the review objectives, namely
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28 317 experiences of using upper limb rehabilitation robots by patients after a stroke and
29
30 318 rehabilitation professionals' experiences of providing stroke upper limb rehabilitation using
31
32 319 robots. The findings, and their illustrations, will be extracted verbatim and assigned a level
33
34 320 of credibility. Any disagreements that arise between the reviewers will be resolved through
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36 321 discussion with the third reviewer. If necessary, missing or additional data will be requested
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38 322 from the authors. Even after obtaining additional information from the authors, all missing
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40 323 or unclear information that continues to exist will be treated in the review report as missing
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42 324 data.
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50 325 **Data synthesis**

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54 326 Qualitative research findings where possible, will be pooled using JBI SUMARI with the
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56 327 meta-aggregation approach.[35] This will involve the aggregation or synthesis of findings to
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58 328 generate a set of statements representing that aggregation by assembling the findings and
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3 329 categorising these findings based on similarity in meaning. These categories will then be
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6 330 subjected to a synthesis to produce a single comprehensive set of synthesised findings that
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8 331 can be used as a basis for evidence-based practice. Where textual pooling is not possible,
9
10 332 the findings will be presented in a narrative form.

14 333 **Assessing confidence in the findings**

17 334 The final synthesised findings will be graded according to the ConQual approach for
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19 335 establishing confidence in the output of qualitative research synthesis and presented in a
20
21 336 Summary of Findings.[36] The Summary of Findings includes the major elements of the
22
23 337 review and details how the ConQual score is developed. The title, population, phenomena
24
25 338 of interest, and context for the specific review will be included in the summary of findings.
26
27 339 Each synthesised finding from the review will then be presented, along with the type of
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29 340 research informing it, the score for dependability and credibility, and the overall ConQual
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31 341 score.

38 342 **Reflexivity and integrity**

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42 343 Given that this is a review of qualitative studies, it is important to consider the reviewers'
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44 344 assumptions and preconceptions regarding the phenomenon of interest, as well as other
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46 345 potential influences that may affect the review process.

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50 346 This review will be conducted in collaboration. The current review is not funded by public or
51
52 347 private sources, and the review team have declared no conflict of interest. As a result, the
53
54 348 review is not affected by external influences. The review team includes a robotic engineer,
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56 349 an occupational therapist with experience in using rehabilitation robots, an occupational
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3 350 therapist, and a physiotherapist with experience in rehabilitation but not robotics. With the
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6 351 deliberate decision to include reviewers with varying levels of experience with rehabilitation
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8 352 robots and their involvement in all stages of the review process, it is anticipated that any
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10 353 potential influence of individual reviewers' conceptions and preconceptions regarding the
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13 354 phenomenon of interest will be minimised. The review team's experience will provide the
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15 355 necessary expertise for this review.

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19 356 A conscious effort will be made to write memos during the data collection and analysis in
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21 357 order to examine and reflect on the reviewer's engagement.[37] This 'memoing' process will
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23 358 include methodological notetaking to explain the procedural aspect and observational
24
25 359 comments to explain and explore the reviewer's feelings at different stages of the review
26
27 360 process. Moreover, the reviewers have not published a primary qualitative study on the
28
29 361 phenomenon of interest, despite having published primary qualitative studies on other
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31 362 topics. The use of the standardised JBI extraction tool for data extraction and following the
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33 363 standard procedures of the meta-aggregation approach for data synthesis, as well as the
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35 364 above-mentioned process of author reflexivity, based on Flemming and Noyes
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37 365 descriptions,[37] are likely to minimise the impact of the review team's preconceptions.
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39 366 Reflexivity and integrity will be maintained throughout the search, data collection and
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41 367 analysis stages.

42 43 44 368 **Patient and public involvement**

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46 369 Patients and members of the public were not involved in the planning of this protocol.

47 48 49 370 **DISCUSSION**

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3 371 The main aim of this review is to describe the experiences of patients after a stroke and
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6 372 rehabilitation professionals' experiences with upper limb rehabilitation robots. The results
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8 373 from this review are expected to inform better understanding of the use of upper limb
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10 374 rehabilitation robots, perceptions, opinions, facilitators, and barriers to their use. This
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13 375 review will highlight current research and available evidence in this important and emerging
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15 376 topic area in upper limb rehabilitation after a stroke. The findings from this review will be
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17 377 published and disseminated in journals, conferences and social media, and it is anticipated
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19 378 that the findings from this review will be useful for patients after a stroke, rehabilitation
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21 379 professionals, commissioners of health and care services and developers of rehabilitation
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23 380 robots to inform better provision and ongoing care for patients after a stroke.
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29 **FIGURE LEGENDS:**

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32 382 **Figure 1** illustrates an example of upper limb training using an end-effector robot, H-man.

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35 383 *Note: The person shown in the picture is not a patient and was taken with the participant's
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37 384 knowledge and permission. Picture courtesy of Articares.

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41 385 **Figure 2** illustrates an example of upper limb training using an end-effector robot,

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43 386 MO.TO.RE. *Note: The person shown in the picture is not a patient and was taken with the
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45 387 participant's knowledge and permission. Picture courtesy of Humanware S.r.l.

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49 388 **Figure 3** illustrates an example of upper limb training using an exoskeleton robot,

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51 389 ArmeoPower. *Note: The person shown in the picture is not a patient and was taken with
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53 390 the participant's knowledge and permission. Picture courtesy of Hocoma.

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3 391 **Figure 4** illustrates an example of an upper limb exosuit robot described by Hoang et al.
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6 392 being worn by a volunteer. *Note: The person shown in the picture is not a patient and was
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8 393 taken with the participant's knowledge and permission. Picture courtesy of Dr Thanh Nho
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14 395 **ABBREVIATIONS:**

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17 396 CINAHL: Cumulative Index of Nursing and Allied Health Literature

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20 397 PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

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22 398 PROSPERO: International Prospective Register of Systematic Reviews

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25 399 JBI SUMARI: JBI System for the Unified Management, Assessment and Review of
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27 400 Information

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31 401 **AUTHOR CONTRIBUTIONS:**

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33
34 402 MC was responsible for the conceptualisation and design of the study with critical inputs

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36
37 403 from LV, VS, and SB. MC developed the search strategy and conducted the search with

38
39 404 critical input from LV, VS, and SB. The protocol was drafted by MC with important

40
41 405 intellectual input and revisions from LV, VS, and SB. All authors have read and given

42
43
44 406 approval for this version and agree to be accountable for all aspects of the work. MC is the
45
46 407 guarantor of the review.

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48
49
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51
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53
54 409 This research received no specific grant from any funding agency in the public, commercial

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56 410 or not-for-profit sectors.
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3 411 **CONFLICT OF INTERESTS STATEMENT:**
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7 412 The authors declare that there are no competing interests or conflicting interests.
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9

10 413 **DATA STATEMENT:**
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14 414 There are currently no data associated with this protocol. However, this protocol is

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16 415 published in PROSPERO. Details of this citation are as follows
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20 416 Manigandan Chockalingam, Lenny Vasanthan T, Sivakumar Balasubramanian, Vimal Sriram.

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22 417 Stroke patients and their healthcare providers' experiences of upper limb rehabilitation
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30 420 from: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42022321402
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Figure 1 illustrates an example of upper limb training using an end-effector robot, H-man. *Note: The person shown in the picture is not a patient and was taken with the participant's knowledge and permission. Picture courtesy of Articares.

724x254mm (300 x 300 DPI)

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Figure 2 illustrates an example of upper limb training using an end-effector robot, MO.TO.RE. *Note: The person shown in the picture is not a patient and was taken with the participant's knowledge and permission. Picture courtesy of Humanware S.r.l.

721x265mm (300 x 300 DPI)



Figure 3 illustrates an example of upper limb training using an exoskeleton robot, ArmeoPower. *Note: The person shown in the picture is not a patient and was taken with the participant's knowledge and permission. Picture courtesy of Hocoma.

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Figure 4 illustrates an example of an upper limb exosuit robot described by Hoang et al. being worn by a volunteer. *Note: The person shown in the picture is not a patient and was taken with the participant's knowledge and permission. Picture courtesy of Dr Thanh Nho Do.

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Ovid MEDLINE(R) ALL <1946 to May 20, 2022>

1 exp Psychiatrists/ or exp Health Personnel/ or exp Allied Health Personnel/ or exp Physicians/
 2 or exp Primary Health Care/ or exp Nurses/ or exp Family Nurse Practitioners/ or exp Nurse
 3 Practitioners/ or exp Physical Therapists/ or exp Occupational Therapists/ or health personnel.mp. or
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 5 allied health professional*.mp. or doctor*.mp. or physician*.mp. or geriatric*.mp. or rescriber*.mp.
 6 or primary healthcare.mp. or paramedic*.mp. or family nurse.mp. or nurse.mp. or community
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 12 healthcare).mp. (Records Retrieved – 7196481)

2 exp "Attitude of Health Personnel"/ or exp Attitude/ or exp Occupational Stress/ or exp
 3 "Delivery of Health Care"/ or exp Qualitative Research/ or experience*.mp. or feel*.mp. or
 4 encounter*.mp. or perception*.mp. or opinion*.mp. (Records Retrieved – 3027183)

5 1 and 2 (Records Retrieved – 1094496)

6 exp "Quality of Health Care"/ or exp Patient Satisfaction/ or exp Patient Compliance/ or exp
 7 Compliance/ or exp "Patient Acceptance of Health Care"/ or exp "Treatment Adherence and
 8 Compliance"/ or exp Patient Dropouts/ or exp Treatment Refusal/ or exp Patient Participation/ or
 9 exp Psychological Distress/ or exp Health Behavior/ or exp "Quality of Life"/ or exp Attitude/ or exp
 10 Qualitative Research/ or patient satisfaction.mp. or patient acceptance.mp. or patient dropout*.mp.
 11 or patient participation.mp. or treatment refus*.mp. or experience*.mp. or feel*.mp. or
 12 encounter*.mp. or perception*.mp. or opinion*.mp. (Records Retrieved – 9171170)

13 3 or 4 (Records Retrieved – 9292409)

14 exp cerebrovascular disorders/ or exp basal ganglia cerebrovascular disease/ or exp brain
 15 ischemia/ or exp carotid artery diseases/ or exp cerebral small vessel diseases/ or exp intracranial
 16 arterial diseases/ or exp "intracranial embolism and thrombosis"/ or exp intracranial hemorrhages/
 17 or stroke/ or exp brain infarction/ or stroke, lacunar/ or vasospasm, intracranial/ or vertebral artery
 18 dissection/ or brain injuries/ or brain injury, chronic/ or (stroke* or poststroke or apoplex* or
 19 cerebral vasc* or brain vasc* or cerebrovasc* or cva* or SAH).mp. or ((brain or cerebr* or cerebell*
 20 or vertebrobasil* or hemispher* or intracran* or intracerebral or infratentorial or supratentorial or
 21 middle cerebral artery or MCA* or anterior circulation or posterior circulation or basilar artery or
 22 vertebral artery or space-occupying) adj5 (isch?emi* or infarct* or thrombo* or emboli* or occlus*
 23 or hypoxi*).mp. or ((brain* or cerebr* or cerebell* or intracerebral or intracran* or parenchymal or
 24 intraparenchymal or intraventricular or infratentorial or supratentorial or basal gangli* or putaminal
 25 or putamen or posterior fossa or hemispher* or subarachnoid) adj5 (h?emorrhag* or h?ematoma*
 26 or bleed*).mp. or hemiplegia/ or exp paresis/ or (hemipleg* or hemipar* or paresis or paretic or
 27 brain injur*).mp. (Records Retrieved – 805510)

28 exp upper extremity/ or (upper limb* or upper extremit* or arm or arms or shoulder or
 29 shoulders or hand or hands or axilla* or elbow* or forearm* or finger* or wrist*).mp. (Records
 30 Retrieved – 1087124)

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3 8 robotics/ or automation/ or orthotic devices/ or "equipment and supplies"/ or self-help
4 devices/ or therapy, computer-assisted/ or man-machine systems/ or (robot* or orthos* or orthotic
5 or automat* or computer aided or computer assisted or device*).mp. or (electromechanical or
6 electro-mechanical or mechanical or mechanised or mechanized or driven).mp. or exercise
7 movement techniques/ or exercise/ or exercise therapy/ or muscle stretching techniques/ or motion
8 therapy, continuous passive/ or ((continuous passive or cpm) adj3 therap*).mp. or (assist* adj5
9 (train* or aid* or rehabilitat* or re-educat*).mp. (Records Retrieved – 2054580)
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12 9 5 and 6 and 7 and 8 (Records Retrieved – 4059)
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S1 Table: Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Systematic Reviews 2015 4:1

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
ADMINISTRATIVE INFORMATION					
Title					
Identification	1a	Identify the report as a protocol of a systematic review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	4, 50
Update	1b	If the protocol is for an update of a previous systematic review, identify as such	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A.
Registration	2	If registered, provide the name of the registry (e.g., PROSPERO) and registration number in the Abstract	<input checked="" type="checkbox"/>	<input type="checkbox"/>	79, 269-270, 414-420
Authors					
Contact	3a	Provide name, institutional affiliation, and e-mail address of all protocol authors; provide physical mailing address of corresponding author	<input checked="" type="checkbox"/>	<input type="checkbox"/>	5-42
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	401-407
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
Support					
Sources	5a	Indicate sources of financial or other support for the review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	408-410
Sponsor	5b	Provide name for the review funder and/or sponsor	<input checked="" type="checkbox"/>	<input type="checkbox"/>	408-410
Role of sponsor/funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol	<input checked="" type="checkbox"/>	<input type="checkbox"/>	408-410
INTRODUCTION					
Rationale	6	Describe the rationale for the review in the context of what is already known	<input checked="" type="checkbox"/>	<input type="checkbox"/>	111-172

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	174 -178
METHODS					
Eligibility criteria	8	Specify the study characteristics (e.g., PICO, study design, setting, time frame) and report characteristics (e.g., years considered, language, publication status) to be used as criteria for eligibility for the review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	185- 265
Information sources	9	Describe all intended information sources (e.g., electronic databases, contact with study authors, trial registers, or other grey literature sources) with planned dates of coverage	<input checked="" type="checkbox"/>	<input type="checkbox"/>	280-286
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	<input checked="" type="checkbox"/>	<input type="checkbox"/>	271-286 and Appendix 1
STUDY RECORDS					
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	287-367
Selection process	11b	State the process that will be used for selecting studies (e.g., two independent reviewers) through each phase of the review (i.e., screening, eligibility, and inclusion in meta-analysis)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	287-302
Data collection process	11c	Describe planned method of extracting data from reports (e.g., piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators	<input checked="" type="checkbox"/>	<input type="checkbox"/>	312-324
Data items	12	List and define all variables for which data will be sought (e.g., PICO items, funding sources), any pre-planned data assumptions and simplifications	<input type="checkbox"/>	<input checked="" type="checkbox"/>	312-324
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
		prioritization of main and additional outcomes, with rationale			
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis	<input checked="" type="checkbox"/>	<input type="checkbox"/>	303-311
DATA					
Synthesis	15a	Describe criteria under which study data will be quantitatively synthesized	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data, and methods of combining data from studies, including any planned exploration of consistency (e.g., I^2 , Kendall's tau)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
	15c	Describe any proposed additional analyses (e.g., sensitivity or subgroup analyses, meta-regression)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned	<input checked="" type="checkbox"/>	<input type="checkbox"/>	325-332
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (e.g., publication bias across studies, selective reporting within studies)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (e.g., GRADE)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	333-341

S1 Table: Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Systematic Reviews 2015 4:1

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
ADMINISTRATIVE INFORMATION					
Title					
Identification	1a	Identify the report as a protocol of a systematic review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	4, 50
Update	1b	If the protocol is for an update of a previous systematic review, identify as such	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A.
Registration	2	If registered, provide the name of the registry (e.g., PROSPERO) and registration number in the Abstract	<input checked="" type="checkbox"/>	<input type="checkbox"/>	798, 2692-27063, 38414-39420
Authors					
Contact	3a	Provide name, institutional affiliation, and e-mail address of all protocol authors; provide physical mailing address of corresponding author	<input checked="" type="checkbox"/>	<input type="checkbox"/>	5-42
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	37401-37407
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
Support					
Sources	5a	Indicate sources of financial or other support for the review	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	37408-38410
Sponsor	5b	Provide name for the review funder and/or sponsor	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	37408-38410
Role of sponsor/funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	37408-38410
INTRODUCTION					

Commented [MC1]: Under support items- I would suggest here selecting the "Yes" answer. Even though you may not have a funder, etc., this information is included in the manuscript/protocol (lines 378-380, as you have noted).

Suggested changes have been made.

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
Rationale	6	Describe the rationale for the review in the context of what is already known	<input checked="" type="checkbox"/>	<input type="checkbox"/>	1106-17266
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	17468 - 17872
METHODS					
Eligibility criteria	8	Specify the study characteristics (e.g., PICO, study design, setting, time frame) and report characteristics (e.g., years considered, language, publication status) to be used as criteria for eligibility for the review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	18579- 2659
Information sources	9	Describe all intended information sources (e.g., electronic databases, contact with study authors, trial registers, or other grey literature sources) with planned dates of coverage	<input checked="" type="checkbox"/>	<input type="checkbox"/>	28073-28679
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	<input checked="" type="checkbox"/>	<input type="checkbox"/>	27164-28679 and Appendix 1
STUDY RECORDS					
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	2870-36734
Selection process	11b	State the process that will be used for selecting studies (e.g., two independent reviewers) through each phase of the review (i.e., screening, eligibility, and inclusion in meta-analysis)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	2870-30295
Data collection process	11c	Describe planned method of extracting data from reports (e.g., piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators	<input checked="" type="checkbox"/>	<input type="checkbox"/>	31205-32447
Data items	12	List and define all variables for which data will be sought (e.g., PICO items,	<input type="checkbox"/>	<input checked="" type="checkbox"/>	31205-32447

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
		funding sources), any pre-planned data assumptions and simplifications			
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis	<input checked="" type="checkbox"/>	<input type="checkbox"/>	296- 304 303-311
DATA					
Synthesis	15a	Describe criteria under which study data will be quantitatively synthesized	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data, and methods of combining data from studies, including any planned exploration of consistency (e.g., I^2 , Kendall's tau)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
	15c	Describe any proposed additional analyses (e.g., sensitivity or subgroup analyses, meta-regression)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned	<input checked="" type="checkbox"/>	<input type="checkbox"/>	318-325- 332
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (e.g., publication bias across studies, selective reporting within studies)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (e.g., GRADE)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	326- 334 333-341

BMJ Open

The experiences of stroke patients and rehabilitation professionals with upper limb rehabilitation robots: a qualitative systematic review protocol

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2022-065177.R2
Article Type:	Protocol
Date Submitted by the Author:	02-Sep-2022
Complete List of Authors:	Chockalingam, Manigandan; National University of Ireland Galway, Occupational Therapy Vasanthan, Lenny; Christian Medical College Vellore, Physiotherapy, Physical Medicine and Rehabilitation Balasubramanian, Sivakumar ; Christian Medical College Vellore, Bioengineering Sriram, Vimal; University Hospitals Bristol and Weston NHS Foundation Trust, Head of Allied Health Professionals
Primary Subject Heading:	Qualitative research
Secondary Subject Heading:	Neurology, Qualitative research, Rehabilitation medicine
Keywords:	Stroke < NEUROLOGY, REHABILITATION MEDICINE, QUALITATIVE RESEARCH

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TITLE PAGE**1**
2 Title of the article:

3 The experiences of stroke patients and rehabilitation professionals with upper limb
4 rehabilitation robots: a qualitative systematic review protocol

5 Authors

6 Manigandan Chockalingam

7 Lecturer in Occupational Therapy

8 School of Health Sciences

9 R.No. 213 Moyola Building

10 National University of Ireland Galway

11 Galway

12 Ireland

13 Email: Manigandan.Chockalingam@nuigalway.ie; manigandan93@yahoo.com

14 Lenny Vasanthan

15 Reader in Physiotherapy

16 Christian Medical College, Vellore

17 Vellore – 632004

18 India

19 Email: lennyv@cmcvellore.ac.in

20 Sivakumar Balasubramanian

21 Professor and Head of Bioengineering

22 Christian Medical College

1
2
3 23 Bagayam
4
5
6 24 Vellore – 632002
7
8
9 25 India
10
11
12 26 Email: siva82kb@cmcvellore.ac.in
13
14
15
16 27 Vimal Sriram
17
18 28 Head of Allied Health Professionals
19
20 29 University Hospitals Bristol and Weston NHS Foundation Trust
21
22
23 30 Trust HQ
24
25 31 Marlborough Hill
26
27
28 32 Bristol, BS1 3NU
29
30 33 Email: vimal.sriram@uhbw.nhs.uk
31
32
33
34 **Corresponding Author:**
35
36 35 Lenny Vasanthan
37
38 36 Reader in Physiotherapy
39
40 37 Christian Medical College, Vellore
41
42 38 Ida Scudder Road
43
44 39 Vellore 632 004
45
46 40 Tamil Nadu
47
48 41 India
49
50 42 Email: lennyv@cmcvellore.ac.in
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57 **Word Count**
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59 44 Abstract – 297
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48 proofreading our manuscript and for valuable English language editing.

For peer review only

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2
3 49 **The experiences of stroke patients and rehabilitation professionals with**
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6 50 **upper limb rehabilitation robots: a qualitative systematic review protocol**
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10 51 **ABSTRACT**
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13 52 **Introduction:** Emerging evidence suggests that robotic devices for upper limb rehabilitation
14
15 53 after a stroke may improve upper limb function. For robotic upper limb rehabilitation in
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17 54 stroke to be successful, patients' experiences and those of the rehabilitation professionals
18
19 55 must be considered. Therefore, this review aims to synthesise the available evidence on
20
21 56 experiences of patients after a stroke with rehabilitation robots for upper limb rehabilitation
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23 57 and the experiences of rehabilitation professionals with rehabilitation robots for upper limb
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25 58 stroke rehabilitation.
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31 59 **Methods and Analysis:** Database search will include MEDLINE(Ovid), EMBASE(Elsevier),
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33 60 Cochrane CENTRAL, PsycINFO, Scopus, Web of Science, IEEE and CINAHL(EBSCOhost). Grey
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35 61 literature from Open Grey, PsyArXiv, bioRxiv, medRxiv, and Google Scholar, will also be
36
37 62 searched. Qualitative studies or results from mixed-method studies that include adult
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39 63 patients after a stroke who use upper limb rehabilitation robots, either supervised by
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41 64 rehabilitation professionals or by patients themselves, at any stage of their rehabilitation
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43 65 and/or stroke professionals who use upper limb rehabilitation robots will be included.
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45 66 Robotic upper limb rehabilitation provided by students, healthcare assistants, technicians,
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47 67 non-professional caregivers, family caregivers, volunteer caregivers, or other informal
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49 68 caregivers will be excluded. Articles published in English will be considered regardless of
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51 69 date of publication. Studies will be screened and critically appraised for methodological
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53 70 quality by two independent reviewers. A standardised tool from JBI SUMARI for data
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3 71 extraction, the meta-aggregation approach for data synthesis, and the ConQual approach
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6 72 for confidence evaluation will be followed.
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9 73 **Ethics and Dissemination:** As this systematic review is based on previously published
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11 74 research, no informed consent or ethical approval is required. It is anticipated that this
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14 75 systematic review will highlight the experiences of patients after a stroke and perceived
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16 76 facilitators and barriers for rehabilitation professionals on this topic, which will be
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19 77 disseminated through peer-reviewed publications and national and international
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21 78 conferences.
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25 79 **Systematic review registration number:** PROSPERO-CRD42022321402
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28 80 **Keywords:** robotics; stroke; rehabilitation; experience; health personnel
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32 81 **Abstract word count:** 297
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3 **82 ARTICLE SUMMARY**
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7 **83 STRENGTHS AND LIMITATIONS OF THIS STUDY**
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- 10 84 1. This review will include literature from inter-disciplinary databases to maximise
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13 85 diversity of data.
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15 86 2. Inclusion of grey literature in this review will provide comprehensive information of
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18 87 experiences in the use of upper limb rehabilitation robots that are not commercially
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20 88 available.
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23 89 3. Use of ConQual approach will ensure confidence in the synthesised findings of this
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25 90 review.
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28 91 4. This review will include only English-language publications due to limited financial
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30 92 resources, which will limit the review's comprehensiveness.
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93 INTRODUCTION

94 The use of rehabilitation robots has grown over the past few decades,[1] particularly for
95 upper limb stroke rehabilitation, and the evidence supporting their use is also
96 increasing.[2,3] Several rehabilitation robots are available to assess and augment
97 rehabilitation of stroke-impaired upper limbs under direct or remote supervision, including
98 end-effectors,[4,5] (Figure 1 and Figure 2) exoskeletons,[6] (Figure 3) and exosuits.[7]
99 (Figure 4) The use of rehabilitation robots produces comparable results,[8] and in some
100 cases, such as when used by individuals with upper extremity hemiplegia, who have limited
101 chances of spontaneous recovery after stroke, they could produce better results than those
102 achieved by other routine therapy methods.[2,3] In addition, systematic reviews of
103 rehabilitation robots in upper limb stroke rehabilitation have demonstrated that they
104 provide valid outcome measurements of clinically meaningful body functions and structures
105 of the ICF domain, such as muscle viscoelasticity[9] and movement-related kinematic
106 parameters.[10] For these reasons, rehabilitation robots are receiving increasing attention
107 in rehabilitation programs as intervention devices and tools for evaluating clinical outcomes.
108 Although rehabilitation robots have not been extensively examined for their adoption in
109 routine care, the increasing number of robots being commercialised over the past decade
110 and the increased number of robotic literature suggests a slow and steady adoption.[11]
111 There is some emerging evidence that rehabilitation robots may improve upper limb
112 function after a stroke.[1-3] Studies have compared different types of robots in concluding
113 effectiveness of upper limb function,[8,12] which may explain the varying results between
114 studies that support or negate the effectiveness of upper limb robotic rehabilitation.
115 Mehrholz et al., for example, reported that there is no difference between the types of

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3 116 robots and the improvements in upper limb functional performance in their meta-analysis
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6 117 of robot-assisted upper limb training in patients after a stroke.[8] In contrast, the meta-
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8 118 analysis by Mogio et al. found that exoskeleton robots are significantly superior to end-
9
10 119 effector robots in improving finger and hand motor function in patients after a stroke.[12] It
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13 120 should be noted that the use of Exosuits in rehabilitation is a relatively new approach in
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15 121 rehabilitation robotics, and no comparison studies have been completed to date.[7,13,14]
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19 122 Due to the variety of robots available that provide similar clinical outcomes, selecting an
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21 123 appropriate robotic intervention strategy for patients after a stroke by rehabilitation
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23 124 professionals may be complex and challenging.[8] Thus, the subjective experiences of
24
25 125 rehabilitation professionals with robots become crucial in the selection and use of
26
27 126 rehabilitation robots in clinical practice. It is also pertinent to study rehabilitation
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29 127 professionals' experiences with and attitudes towards using rehabilitation robots in clinical
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31 128 practice since they remain cautious when recommending them.[15,16] The literature also
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33 129 acknowledges this need, pointing out that rehabilitation professionals' attitudes are as
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35 130 important as the benefits derived from robots.[15,16] If upper limb rehabilitation robots are
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37 131 to be successfully incorporated into clinical practice, there is a need for a systematic
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39 132 approach to the adoption of such robots in rehabilitation.[15,16] Therefore, it is necessary
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41 133 to systematically review, document, and compile rehabilitation professionals' perspectives,
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43 134 experiences, and views on upper limb rehabilitation robots.
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51 135 Renaud and Van Biljon assert that a person's adoption of technology begins when they
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53 136 become aware of it and ends when they accept and fully utilise it.[17] The perceptions,
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55 137 perspectives, satisfaction and other experiences of an end user play a significant role in
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57 138 determining whether that end user will successfully adopt the technology and whether the
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3 139 technology will continue to be used or discontinued.[18] Thus, the experiences of patients
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5 140 who use rehabilitation robots after a stroke are as significant as those of rehabilitation
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7 141 professionals. The experiences of patients with rehabilitation robots may differ from those
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9 142 of rehabilitation professionals, and therefore, these experiences should be analysed and
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11 143 reported separately. After a stroke, patients tend to prioritise their personal needs and
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13 144 participation in meaningful activities over that of impairment-focused rehabilitation.[19] It
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15 145 is, therefore, imperative to conduct a comprehensive review of patient experiences related
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17 146 to the use of rehabilitation robots, which may lead to an increase in the acceptance and
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19 147 sustained use of these devices by informing improved user-centred designs. Further, a
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21 148 comprehensive summary of patients' likes, dislikes, and preferences for specific upper limb
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23 149 rehabilitation robots is fundamental when outcomes among the types of robots are largely
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25 150 similar.[8]

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33 151 The only systematic review to date that aimed to meta-synthesise end-user perceptions of
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35 152 robotics is in motor rehabilitation[20] and provides an early, generic description of the
36
37 153 patients', caregivers', and professionals' experiences with rehabilitation robots. In the
38
39 154 review by Lapidou et al., an overview of all types of motor rehabilitation using
40
41 155 rehabilitation robots for various clinical conditions (shoulder instability/rotator cuff injury,
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43 156 spinal cord injury, stroke, brain injury, cerebral palsy, and unspecified clinical conditions) of
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45 157 all ages (from five to 84 years of age) is provided.[20] This review's inclusion of participants
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47 158 with varied clinical presentations offers valuable insight into their generalised experiences
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49 159 with rehabilitation robots. However, as the review focuses on a broad clinical group, it fails
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51 160 to provide a comprehensive focus and in-depth description of rehabilitation robots' use in
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53 161 adult patients with stroke. Stroke upper limb rehabilitation robots for adults require
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3 162 particular considerations due to their unique needs,[21] abilities,[22] and patterns of
4
5
6 163 functional recovery[23] that are distinct from those of other patient populations, such as
7
8 164 spinal cord injury[24,25] or children with cerebral palsy.[26] This work addresses the lack of
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10
11 165 an in-depth focus on patients with stroke to fill the gap in the literature that so far has
12
13 166 predominantly looked at multiple clinical conditions.

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17 167 A preliminary search of PROSPERO, MEDLINE, Cochrane Database of Systematic Reviews,
18
19 168 and JBI Evidence Synthesis was conducted on 01 March 2022. During the search, no scoping
20
21 169 or systematic reviews were identified that focused on the experiences of the use of upper
22
23
24 170 limb rehabilitation robots by stroke patients or their rehabilitation professionals, indicating
25
26 171 the necessity for a qualitative systematic review to further explore this.

30 172 **METHODS AND ANALYSIS**

32 173 **Objective**

36 174 This review aims to collect and synthesise available evidence regarding the experiences of
37
38 175 patients after a stroke using robots for upper limb rehabilitation, irrespective of the ongoing
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41 176 involvement of rehabilitation professionals and the experiences of rehabilitation
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43 177 professionals using robots for upper limb stroke rehabilitation.

47 178 **Review questions**

- 51 179 1. What are the experiences of patients after a stroke when undergoing rehabilitation
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53 180 for upper limb dysfunction using rehabilitation robots?

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3 181 2. What are the rehabilitation professionals' experiences, perspectives, opinions, and
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6 182 perceived facilitators and barriers regarding the use of rehabilitation robots for
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8 183 upper limb stroke rehabilitation?
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12 184 **Eligibility criteria**

13
14 185 **Participants**

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18 186 This review will consider studies that include adult patients (over the age of 18) after a
19
20 187 stroke using rehabilitation robots for upper limb rehabilitation, either supervised by
21
22
23 188 rehabilitation professionals or by patients themselves, as part of self-administered robotic
24
25 189 therapy at any phase of their rehabilitation.
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28
29 190 To clarify our inclusion criteria, we have used the following definitions:
30

31
32 191 *Stroke* – a sudden loss of neurological function caused by haemorrhage or ischemia in the
33
34
35 192 brain parenchyma caused by a vascular event, with symptoms lasting more than 24 hours,
36
37 193 which are not explainable by other causes.
38

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40
41 194 *Phases of rehabilitation* – time after stroke as classified by the Stroke Roundtable

42
43 195 Consortium;^[27] namely, the hyperacute phase (< 24 hours), the acute phase (2-7 days), the
44
45
46 196 early subacute phase (8-90 days), late subacute phase (91-180 days) and chronic phase
47
48 197 (>180 days).
49

50
51
52 198 *Upper limb rehabilitation* – interventions aimed at enhancing the function of the upper limb
53
54 199 after considering the goals of patients after a stroke, which are identified following
55
56
57 200 evaluations of their functional abilities and level of activity.
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3 201 *Rehabilitation robots* – robots that have contact with a patient to provide physical
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5
6 202 interaction driven by an actuation system and controlled by the robot alone or in a robot
7
8 203 and patient shared control to perform rehabilitation, assessment, compensation, or
9
10 204 alleviation.[28] Rehabilitation robots may be fixed, mobile, or wearable devices used during
11
12
13 205 inpatient, outpatient, home-based, or community-based rehabilitation. These rehabilitation
14
15 206 robots may take the forms of end-effectors, exoskeletons, or exosuits.

17
18
19 207 *End-effectors* – robots with a single point of connection to a patient's distal segment, with
20
21 208 joints that are neither matched to nor aligned with other joints of the patient, where the
22
23
24 209 force generated by the robot's distal interface is transmitted to other joints of the patient in
25
26 210 accordance with the principles of close-kinematic chains.[29] (Figure 1 and Figure 2)

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28
29
30 211 *Exoskeletons* – robots with rigid anthropomorphic structures attached to the body at
31
32 212 multiple points through straps, cuffs, belts, or other attachments, ensuring the robotic joint
33
34 213 axes are aligned with the anatomical joints of the wearer's body.[29] (Figure 3)

35
36
37
38 214 *Exosuits* – robots that use softer materials such as fabric instead of rigid anthropomorphic
39
40 215 structures.[29] (Figure 4)

41
42
43
44 216 *Upper limb robotic rehabilitation* – robots assisting or resisting movement in a single joint or
45
46 217 controlling the intersegmental coordination of the affected upper limb as well as providing
47
48 218 and enhancing repetitive task training and task-specific training to improve range of motion,
49
50 219 strength, motor learning, and motor control.[8,29] In addition to assessing, compensating
51
52 220 for, or alleviating the effects of stroke-related upper limb impairment.
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3 221 Studies that report patients with more than one stroke, patients under 18, or patients with
4
5 222 other known causes of upper limb impairment besides stroke will be excluded. Studies
6
7 223 reporting patients without upper limb motor dysfunction or having sensory impairments
8
9 224 alone or cognitive and perceptual impairments alone will be excluded. Hospital robots,
10
11 225 social robots, or care/assistive robots that assist patients after a stroke in their activities of
12
13 226 daily living without being connected to their upper limb or robotic interventions other than
14
15 227 rehabilitation robots, as previously described, will be excluded. Studies reporting upper limb
16
17 228 rehabilitation using rehabilitation robots in body segments other than the affected upper
18
19 229 limb will be excluded. Likewise, studies reporting upper limb robotic interventions
20
21 230 conducted concurrently with other robotic interventions for other body segments,
22
23 231 presented as a whole and not sufficiently distinguished from one another, will be excluded.
24
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28
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30
31 232 This review will include professionals who provide stroke upper limb rehabilitation using
32
33 233 rehabilitation robots. The rehabilitation professionals may be experts in upper limb
34
35 234 rehabilitation, such as physiatrists, physical therapists, occupational therapists, hand
36
37 235 therapists, or rehabilitation nurses. Other professionals such as emergency physicians,
38
39 236 geriatricians, neurologists, neurosurgeons, or other physicians involved only in the medical
40
41 237 or surgical management of patients with stroke who do not provide active upper limb
42
43 238 rehabilitation will be excluded. Similarly, rehabilitation engineers, robotic engineers,
44
45 239 biomedical engineers, orthotists, and other specialists who are typically not directly involved
46
47 240 in physical rehabilitation or clinical care for stroke patients will also be excluded. Robotic
48
49 241 upper limb rehabilitation provided by students, healthcare assistants, or technicians, who
50
51 242 may not be competent to practice independently, will be excluded. Likewise, robotic upper
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3 243 limb rehabilitation provided by non-professional caregivers, family caregivers, volunteer
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6 244 caregivers, or other informal caregivers will also be excluded.
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8

9 245 Phenomena of interest
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13 246 In this review, studies that describe the experiences of patients after a stroke and/or their
14
15 247 rehabilitation professional with upper limb rehabilitation robots will be considered. Patients'
16
17 248 experiences during or after the use of upper limb rehabilitation robots for stroke can be
18
19
20 249 positive or negative, describe complications/adverse events or any other experiences.
21
22 250 Rehabilitation professionals' experiences may include facilitators and barriers, encounters,
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24
25 251 perspectives, or opinions associated with preparing for or providing upper limb
26
27 252 rehabilitation in stroke using rehabilitation robots.
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31 253 Context
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35 254 The context will not be restricted in this review. This review will consider studies that
36
37 255 present patients after a stroke or rehabilitation professionals' experiences of providing
38
39 256 upper limb rehabilitation using rehabilitation robots in any clinical setting during any phase
40
41
42 257 of stroke rehabilitation. These settings may include outpatient, inpatient, community-based,
43
44 258 or home-based intervention services or other therapeutic settings. This review is not
45
46
47 259 restricted to geographical locations, funding mechanisms, healthcare facilities, or services.
48
49
50

51 260 Types of studies
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54 261 This review will consider studies that focus on qualitative data, including, but not limited to,
55
56 262 designs such as qualitative descriptive, phenomenology, grounded theory, ethnography, and
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1
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3 263 action research. This review will also consider the qualitative results of mixed-method
4
5
6 264 studies.

7
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9 265 **Methods**

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13 266 The proposed systematic review will be conducted in accordance with the JBI methodology
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15 267 for systematic reviews of qualitative evidence.[30] The review will commence in October
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17
18 268 2022 and end in September 2023. The review protocol is registered in PROSPERO
19
20 269 (CRD42022321402).

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24 270 **Search strategy**

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26
27 271 The search strategy will aim to locate both published and unpublished studies. A three-step
28
29
30 272 search strategy will be utilised in this review. First, a pilot initial limited search of MEDLINE
31
32 273 (Ovid) and CINAHL (EBSCOhost) was undertaken to identify articles on the topic. The text
33
34 274 words contained in the titles and abstracts of relevant articles and the index terms (such as
35
36
37 275 MeSH terms) used to describe the articles were used to develop a full search strategy for
38
39
40 276 MEDLINE (Ovid) (see Appendix 1). The search strategy, including all identified keywords and
41
42 277 index terms, will be adapted for each included database and/or information source. The
43
44 278 reference lists of all included sources of evidence will be screened for additional studies.

45
46
47
48 279 Regardless of the publication date, articles published in English will be included to capture
49
50 280 all relevant literature comprehensively. In view of the limited resources available to
51
52
53 281 reviewers to translate literature from other languages, languages other than English will be
54
55 282 excluded in this review. The databases will include MEDLINE(Ovid), EMBASE(Elsevier),
56
57
58 283 Cochrane CENTRAL, PsycINFO, Scopus, Web of Science, IEEE and CINAHL(EBSCOhost). Grey
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1
2
3 284 literature will also be searched through Open Grey, PsyArXiv, bioRxiv, medRxiv, and Google
4
5
6 285 Scholar.

7
8
9 286 **Study selection**

10
11
12 287 After the search, the citations will be collated and uploaded into EndNote X20 (Clarivate
13
14 288 Analytics, PA, USA), and duplicates will be removed. After piloting the eligibility criteria on a
15
16 289 sample of citations (between six and eight articles) to ensure consistency in application,[31]
17
18 290 two independent reviewers (MC and LV) will screen all titles and abstracts to determine if
19
20 291 they meet the review's inclusion criteria and any disagreements will be resolved by mutual
21
22 292 agreement in discussion with the third reviewer (VS/SB). Potentially relevant studies will be
23
24 293 retrieved in full, and their citation details imported into the JBI System for the Unified
25
26 294 Management, Assessment and Review of Information (JBI SUMARI) (JBI, Adelaide,
27
28 295 Australia).[32] The full text of selected citations will be assessed in detail against the
29
30 296 inclusion criteria by two independent reviewers (MC and LV), and any disagreements will be
31
32 297 resolved in discussion with VS/SB. The reasons for the exclusion of full-text papers that do
33
34 298 not meet the inclusion criteria will be recorded and reported. The results of the search and
35
36 299 the study inclusion process will be reported in full in the final systematic review and
37
38 300 presented using a Preferred Reporting Items for Systematic Reviews and Meta-analyses
39
40 301 (PRISMA) flow diagram.[33]

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50 302 **Assessment of methodological quality**

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54 303 Eligible studies will be critically appraised by two independent reviewers for methodological
55
56 304 quality using the standard JBI Critical Appraisal Checklist for Qualitative Research.[34] Any
57
58 305 disagreements that arise between the reviewers will be resolved through discussion with
59
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1
2
3 306 the third reviewer. The results of the critical appraisal will be reported in narrative form and
4
5 307 tables. Regardless of the results of their methodological quality, all studies will be included
6
7
8 308 in the data extraction and synthesis process to ensure that all experiences are captured
9
10 309 comprehensively and no evidence is missed. All major quality issues of the included studies
11
12
13 310 will be presented and discussed in the final review report.
14
15

16 311 **Data extraction**

17
18
19
20 312 Data will be extracted from studies included in the review by two independent reviewers
21
22 313 using the standardised JBI data extraction tool in JBI SUMARI.[32] The data extracted will
23
24 314 include specific details about the population, context, culture, geographical location, study
25
26 315 methods, and the phenomena of interest relevant to the review objectives, namely
27
28 316 experiences of using upper limb rehabilitation robots by patients after a stroke and
29
30 317 rehabilitation professionals' experiences of providing stroke upper limb rehabilitation using
31
32 318 robots. The findings, and their illustrations, will be extracted verbatim and assigned a level
33
34 319 of credibility. Any disagreements that arise between the reviewers will be resolved through
35
36 320 discussion with the third reviewer. If necessary, missing or additional data will be requested
37
38 321 from the authors. Even after obtaining additional information from the authors, all missing
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40 322 or unclear information that continues to exist will be treated in the review report as missing
41
42 323 data.
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50 324 **Data synthesis**

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52
53
54 325 Qualitative research findings where possible, will be pooled using JBI SUMARI with the
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56 326 meta-aggregation approach.[35] This will involve the aggregation or synthesis of findings to
57
58 327 generate a set of statements representing that aggregation by assembling the findings and
59
60

1
2
3 328 categorising these findings based on similarity in meaning. These categories will then be
4
5
6 329 subjected to a synthesis to produce a single comprehensive set of synthesised findings that
7
8 330 can be used as a basis for evidence-based practice. Where textual pooling is not possible,
9
10 331 the findings will be presented in a narrative form.

14 332 **Assessing confidence in the findings**

17 333 The final synthesised findings will be graded according to the ConQual approach for
18 334 establishing confidence in the output of qualitative research synthesis and presented in a
19
20 335 Summary of Findings.[36] The Summary of Findings includes the major elements of the
21
22
23 336 review and details how the ConQual score is developed. The title, population, phenomena
24
25
26
27 337 of interest, and context for the specific review will be included in the summary of findings.
28
29
30 338 Each synthesised finding from the review will then be presented, along with the type of
31
32 339 research informing it, the score for dependability and credibility, and the overall ConQual
33
34
35 340 score.

38 341 **Reflexivity and integrity**

41
42 342 Given that this is a review of qualitative studies, it is important to consider the reviewers'
43
44 343 assumptions and preconceptions regarding the phenomenon of interest, as well as other
45
46
47 344 potential influences that may affect the review process.

49
50 345 This review will be conducted in collaboration. The current review is not funded by public or
51
52 346 private sources, and the review team have declared no conflict of interest. As a result, the
53
54
55 347 review is not affected by external influences. The review team includes a robotic engineer,
56
57
58 348 an occupational therapist with experience in using rehabilitation robots, an occupational
59
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1
2
3 349 therapist, and a physiotherapist with experience in rehabilitation but not robotics. With the
4
5
6 350 deliberate decision to include reviewers with varying levels of experience with rehabilitation
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8 351 robots and their involvement in all stages of the review process, it is anticipated that any
9
10 352 potential influence of individual reviewers' conceptions and preconceptions regarding the
11
12
13 353 phenomenon of interest will be minimised. The review team's experience will provide the
14
15 354 necessary expertise for this review.

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17
18
19 355 A conscious effort will be made to write memos during the data collection and analysis in
20
21 356 order to examine and reflect on the reviewer's engagement.[37] This 'memoing' process will
22
23
24 357 include methodological notetaking to explain the procedural aspect and observational
25
26 358 comments to explain and explore the reviewer's feelings at different stages of the review
27
28
29 359 process. Moreover, the reviewers have not published a primary qualitative study on the
30
31 360 phenomenon of interest, despite having published primary qualitative studies on other
32
33
34 361 topics. The use of the standardised JBI extraction tool for data extraction and following the
35
36 362 standard procedures of the meta-aggregation approach for data synthesis, as well as the
37
38
39 363 above-mentioned process of author reflexivity, based on Flemming and Noyes
40
41 364 descriptions,[37] are likely to minimise the impact of the review team's preconceptions.
42
43
44 365 Reflexivity and integrity will be maintained throughout the search, data collection and
45
46 366 analysis stages.

47 48 49 367 **Patient and public involvement**

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53 368 Patients and members of the public were not involved in the planning of this protocol.
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55

56 57 369 **DISCUSSION** 58 59 60

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2
3 370 The main aim of this review is to describe the experiences of patients after a stroke and
4
5
6 371 rehabilitation professionals' experiences with upper limb rehabilitation robots. The results
7
8 372 from this review are expected to inform better understanding of the use of upper limb
9
10 373 rehabilitation robots, perceptions, opinions, facilitators, and barriers to their use. This
11
12 374 review will highlight current research and available evidence in this important and emerging
13
14 375 topic area in upper limb rehabilitation after a stroke. The findings from this review will be
15
16 376 published and disseminated in journals, conferences and social media, and it is anticipated
17
18 377 that the findings from this review will be useful for patients after a stroke, rehabilitation
19
20 378 professionals, commissioners of health and care services and developers of rehabilitation
21
22 379 robots to inform better provision and ongoing care for patients after a stroke.
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29 380 **FIGURE LEGENDS:**

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32 381 **Figure 1** illustrates an example of upper limb training using an end-effector robot, H-man.

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34
35 382 *Note: The person shown in the picture is not a patient and was taken with the participant's
36
37 383 knowledge and permission. Picture courtesy of Articares.
38
39

40
41 384 **Figure 2** illustrates an example of upper limb training using an end-effector robot,

42
43 385 MO.TO.RE. *Note: The person shown in the picture is not a patient and was taken with the
44
45 386 participant's knowledge and permission. Picture courtesy of Humanware S.r.l.
46
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48
49 387 **Figure 3** illustrates an example of upper limb training using an exoskeleton robot,

50
51 388 ArmeoPower. *Note: The person shown in the picture is not a patient and was taken with
52
53 389 the participant's knowledge and permission. Picture courtesy of Hocoma.
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3 390 **Figure 4** illustrates an example of an upper limb exosuit robot described by Hoang et al.
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6 391 being worn by a volunteer. *Note: The person shown in the picture is not a patient and was
7
8 392 taken with the participant's knowledge and permission. Picture courtesy of Dr Thanh Nho
9
10 393 Do.

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14 394 **ABBREVIATIONS:**

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17 395 CINAHL: Cumulative Index of Nursing and Allied Health Literature

18 396 PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

19
20 397 PROSPERO: International Prospective Register of Systematic Reviews

21
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23 398 JBI SUMARI: JBI System for the Unified Management, Assessment and Review of
24
25
26 399 Information

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31 400 **AUTHOR CONTRIBUTIONS:**

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33
34 401 MC was responsible for the conceptualisation and design of the study with critical inputs
35
36 402 from LV, VS, and SB. MC developed the search strategy and conducted the search with
37
38 403 critical input from LV, VS, and SB. The protocol was drafted by MC with important
39
40 404 intellectual input and revisions from LV, VS, and SB. All authors have read and given
41
42 405 approval for this version and agree to be accountable for all aspects of the work. MC is the
43
44 406 guarantor of the review.

45
46
47
48
49
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51
52
53
54 408 This research received no specific grant from any funding agency in the public, commercial
55
56 409 or not-for-profit sectors.
57
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3 410 **CONFLICT OF INTERESTS STATEMENT:**
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5

6
7 411 The authors declare that there are no competing interests or conflicting interests.
8
9

10 412 **DATA STATEMENT:**
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12

13
14 413 There are currently no data associated with this protocol. However, this protocol is

15
16 414 published in PROSPERO. Details of this citation are as follows
17

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19
20 415 Manigandan Chockalingam, Lenny Vasanthan T, Sivakumar Balasubramanian, Vimal Sriram.

21
22 416 Stroke patients and their healthcare providers' experiences of upper limb rehabilitation

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27 418 Available
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30 419 from: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42022321402
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Figure 1 illustrates an example of upper limb training using an end-effector robot, H-man. *Note: The person shown in the picture is not a patient and was taken with the participant's knowledge and permission. Picture courtesy of Articares.

724x254mm (300 x 300 DPI)

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Figure 2 illustrates an example of upper limb training using an end-effector robot, MO.TO.RE. *Note: The person shown in the picture is not a patient and was taken with the participant's knowledge and permission. Picture courtesy of Humanware S.r.l.

721x265mm (300 x 300 DPI)



Figure 3 illustrates an example of upper limb training using an exoskeleton robot, ArmeoPower. *Note: The person shown in the picture is not a patient and was taken with the participant's knowledge and permission. Picture courtesy of Hocoma.

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Figure 4 illustrates an example of an upper limb exosuit robot described by Hoang et al. being worn by a volunteer. *Note: The person shown in the picture is not a patient and was taken with the participant's knowledge and permission. Picture courtesy of Dr Thanh Nho Do.

618x314mm (300 x 300 DPI)

Ovid MEDLINE(R) ALL <1946 to May 20, 2022>

1 exp Psychiatrists/ or exp Health Personnel/ or exp Allied Health Personnel/ or exp Physicians/
 2 or exp Primary Health Care/ or exp Nurses/ or exp Family Nurse Practitioners/ or exp Nurse
 3 Practitioners/ or exp Physical Therapists/ or exp Occupational Therapists/ or health personnel.mp. or
 4 healthcare professional*.mp. or health-care professional*.mp. or health care professional*.mp. or
 5 allied health professional*.mp. or doctor*.mp. or physician*.mp. or geriatric*.mp. or rescriber*.mp.
 6 or primary healthcare.mp. or paramedic*.mp. or family nurse.mp. or nurse.mp. or community
 7 nurse.mp. or physio*.mp. or physiotherapist.mp. or physio therapist.mp. or physical therapist.mp. or
 8 hand therapist.mp. or self treatment.mp. or (Caregiver support regime therapy or Carer).mp. or
 9 Caregivers/ or (health care professional or health care professionals or health care provider or health
 10 care providers or healthcare provider or healthcare providers or healthcare worker or healthcare
 11 workers or personnel, health or professional, health care or provider, health care or provider,
 12 healthcare).mp. (Records Retrieved – 7196481)

2 exp "Attitude of Health Personnel"/ or exp Attitude/ or exp Occupational Stress/ or exp
 3 "Delivery of Health Care"/ or exp Qualitative Research/ or experience*.mp. or feel*.mp. or
 4 encounter*.mp. or perception*.mp. or opinion*.mp. (Records Retrieved – 3027183)

5 1 and 2 (Records Retrieved – 1094496)

6 exp "Quality of Health Care"/ or exp Patient Satisfaction/ or exp Patient Compliance/ or exp
 7 Compliance/ or exp "Patient Acceptance of Health Care"/ or exp "Treatment Adherence and
 8 Compliance"/ or exp Patient Dropouts/ or exp Treatment Refusal/ or exp Patient Participation/ or
 9 exp Psychological Distress/ or exp Health Behavior/ or exp "Quality of Life"/ or exp Attitude/ or exp
 10 Qualitative Research/ or patient satisfaction.mp. or patient acceptance.mp. or patient dropout*.mp.
 11 or patient participation.mp. or treatment refus*.mp. or experience*.mp. or feel*.mp. or
 12 encounter*.mp. or perception*.mp. or opinion*.mp. (Records Retrieved – 9171170)

13 3 or 4 (Records Retrieved – 9292409)

14 exp cerebrovascular disorders/ or exp basal ganglia cerebrovascular disease/ or exp brain
 15 ischemia/ or exp carotid artery diseases/ or exp cerebral small vessel diseases/ or exp intracranial
 16 arterial diseases/ or exp "intracranial embolism and thrombosis"/ or exp intracranial hemorrhages/
 17 or stroke/ or exp brain infarction/ or stroke, lacunar/ or vasospasm, intracranial/ or vertebral artery
 18 dissection/ or brain injuries/ or brain injury, chronic/ or (stroke* or poststroke or apoplex* or
 19 cerebral vasc* or brain vasc* or cerebrovasc* or cva* or SAH).mp. or ((brain or cerebr* or cerebell*
 20 or vertebrobasil* or hemispher* or intracran* or intracerebral or infratentorial or supratentorial or
 21 middle cerebral artery or MCA* or anterior circulation or posterior circulation or basilar artery or
 22 vertebral artery or space-occupying) adj5 (isch?emi* or infarct* or thrombo* or emboli* or occlus*
 23 or hypoxi*).mp. or ((brain* or cerebr* or cerebell* or intracerebral or intracran* or parenchymal or
 24 intraparenchymal or intraventricular or infratentorial or supratentorial or basal gangli* or putaminal
 25 or putamen or posterior fossa or hemispher* or subarachnoid) adj5 (h?emorrhag* or h?ematoma*
 26 or bleed*).mp. or hemiplegia/ or exp paresis/ or (hemipleg* or hemipar* or paresis or paretic or
 27 brain injur*).mp. (Records Retrieved – 805510)

28 exp upper extremity/ or (upper limb* or upper extremit* or arm or arms or shoulder or
 29 shoulders or hand or hands or axilla* or elbow* or forearm* or finger* or wrist*).mp. (Records
 30 Retrieved – 1087124)

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4 devices/ or therapy, computer-assisted/ or man-machine systems/ or (robot* or orthos* or orthotic
5 or automat* or computer aided or computer assisted or device*).mp. or (electromechanical or
6 electro-mechanical or mechanical or mechanised or mechanized or driven).mp. or exercise
7 movement techniques/ or exercise/ or exercise therapy/ or muscle stretching techniques/ or motion
8 therapy, continuous passive/ or ((continuous passive or cpm) adj3 therap*).mp. or (assist* adj5
9 (train* or aid* or rehabilitat* or re-educat*).mp. (Records Retrieved – 2054580)
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For peer review only

S1 Table: Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Systematic Reviews 2015 4:1

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
ADMINISTRATIVE INFORMATION					
Title					
Identification	1a	Identify the report as a protocol of a systematic review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	4, 50
Update	1b	If the protocol is for an update of a previous systematic review, identify as such	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A.
Registration	2	If registered, provide the name of the registry (e.g., PROSPERO) and registration number in the Abstract	<input checked="" type="checkbox"/>	<input type="checkbox"/>	79, 268-269, 413-419
Authors					
Contact	3a	Provide name, institutional affiliation, and e-mail address of all protocol authors; provide physical mailing address of corresponding author	<input checked="" type="checkbox"/>	<input type="checkbox"/>	5-42
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	400-406
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
Support					
Sources	5a	Indicate sources of financial or other support for the review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	407=409
Sponsor	5b	Provide name for the review funder and/or sponsor	<input checked="" type="checkbox"/>	<input type="checkbox"/>	407=409
Role of sponsor/funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol	<input checked="" type="checkbox"/>	<input type="checkbox"/>	407=409
INTRODUCTION					
Rationale	6	Describe the rationale for the review in the context of what is already known	<input checked="" type="checkbox"/>	<input type="checkbox"/>	111-171

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	173 -177
METHODS					
Eligibility criteria	8	Specify the study characteristics (e.g., PICO, study design, setting, time frame) and report characteristics (e.g., years considered, language, publication status) to be used as criteria for eligibility for the review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	184- 264
Information sources	9	Describe all intended information sources (e.g., electronic databases, contact with study authors, trial registers, or other grey literature sources) with planned dates of coverage	<input checked="" type="checkbox"/>	<input type="checkbox"/>	279-285
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	<input checked="" type="checkbox"/>	<input type="checkbox"/>	270-285 and Appendix 1
STUDY RECORDS					
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	286-366
Selection process	11b	State the process that will be used for selecting studies (e.g., two independent reviewers) through each phase of the review (i.e., screening, eligibility, and inclusion in meta-analysis)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	286-301
Data collection process	11c	Describe planned method of extracting data from reports (e.g., piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators	<input checked="" type="checkbox"/>	<input type="checkbox"/>	311-323
Data items	12	List and define all variables for which data will be sought (e.g., PICO items, funding sources), any pre-planned data assumptions and simplifications	<input type="checkbox"/>	<input checked="" type="checkbox"/>	311-323
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
		prioritization of main and additional outcomes, with rationale			
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis	<input checked="" type="checkbox"/>	<input type="checkbox"/>	302-310
DATA					
Synthesis	15a	Describe criteria under which study data will be quantitatively synthesized	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data, and methods of combining data from studies, including any planned exploration of consistency (e.g., I^2 , Kendall's tau)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
	15c	Describe any proposed additional analyses (e.g., sensitivity or subgroup analyses, meta-regression)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned	<input checked="" type="checkbox"/>	<input type="checkbox"/>	324-331
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (e.g., publication bias across studies, selective reporting within studies)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (e.g., GRADE)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	332-340

S1 Table: Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Systematic Reviews 2015 4:1

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
ADMINISTRATIVE INFORMATION					
Title					
Identification	1a	Identify the report as a protocol of a systematic review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	4, 50
Update	1b	If the protocol is for an update of a previous systematic review, identify as such	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A.
Registration	2	If registered, provide the name of the registry (e.g., PROSPERO) and registration number in the Abstract	<input checked="" type="checkbox"/>	<input type="checkbox"/>	79, 26 89 - 26970, 4134-41920
Authors					
Contact	3a	Provide name, institutional affiliation, and e-mail address of all protocol authors; provide physical mailing address of corresponding author	<input checked="" type="checkbox"/>	<input type="checkbox"/>	5-42
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	4001-4067
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
Support					
Sources	5a	Indicate sources of financial or other support for the review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	408-410 407=409
Sponsor	5b	Provide name for the review funder and/or sponsor	<input checked="" type="checkbox"/>	<input type="checkbox"/>	407=409 408-410
Role of sponsor/funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol	<input checked="" type="checkbox"/>	<input type="checkbox"/>	407=409 408-410
INTRODUCTION					
Rationale	6	Describe the rationale for the review in the context of what is already known	<input checked="" type="checkbox"/>	<input type="checkbox"/>	111-1712

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	17 34 -17 78
METHODS					
Eligibility criteria	8	Specify the study characteristics (e.g., PICO, study design, setting, time frame) and report characteristics (e.g., years considered, language, publication status) to be used as criteria for eligibility for the review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	18 45 - 26 45
Information sources	9	Describe all intended information sources (e.g., electronic databases, contact with study authors, trial registers, or other grey literature sources) with planned dates of coverage	<input checked="" type="checkbox"/>	<input type="checkbox"/>	27 980 -28 56
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	<input checked="" type="checkbox"/>	<input type="checkbox"/>	27 01 -28 56 and Appendix 1
STUDY RECORDS					
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	<input checked="" type="checkbox"/>	<input type="checkbox"/>	28 67 -36 67
Selection process	11b	State the process that will be used for selecting studies (e.g., two independent reviewers) through each phase of the review (i.e., screening, eligibility, and inclusion in meta-analysis)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	28 67 -30 12
Data collection process	11c	Describe planned method of extracting data from reports (e.g., piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators	<input checked="" type="checkbox"/>	<input type="checkbox"/>	31 12 -32 34
Data items	12	List and define all variables for which data will be sought (e.g., PICO items, funding sources), any pre-planned data assumptions and simplifications	<input type="checkbox"/>	<input checked="" type="checkbox"/>	31 12 -32 34
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
		prioritization of main and additional outcomes, with rationale			
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis	<input checked="" type="checkbox"/>	<input type="checkbox"/>	30 23 -31 01
DATA					
Synthesis	15a	Describe criteria under which study data will be quantitatively synthesized	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data, and methods of combining data from studies, including any planned exploration of consistency (e.g., I^2 , Kendall's tau)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
	15c	Describe any proposed additional analyses (e.g., sensitivity or subgroup analyses, meta-regression)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned	<input checked="" type="checkbox"/>	<input type="checkbox"/>	32 45 -33 12
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (e.g., publication bias across studies, selective reporting within studies)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	N/A
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (e.g., GRADE)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	33 23 -34 01