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A systematic review of remote rehabilitation (telerehabilitation) services to support people with vision impairment.

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3 1 **Title:** A systematic review of remote rehabilitation (telerehabilitation) services to
4 support people with vision impairment.
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8
9 4 **Authors:**

10
11 5 Lee Jones ¹, Matthew Lee ^{1,2}, Claire L. Castle ¹, Nikki Heinze ¹, Renata S.M. Gomes
12 1, 3
13
14
15 7

16
17 8 **Affiliations:**

- 18
19
20 9 1. BRAVO VICTOR, Research, 12-14 Harcourt Street, W1H 4HD, London,
21 United Kingdom
22 10 2. Blind Veterans UK, Operations Directorate, 12-14 Harcourt Street, W1H 4HD,
23 11 London, United Kingdom
24 12 3. Northern Hub for Veterans and Military Families Research, Department of
25 13 Nursing, Midwifery and Health, Faculty of Health and Life Sciences,
26 14 Northumbria University, United Kingdom
27 15
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34

35 17 **Corresponding author:** Professor Renata Gomes, Chief Scientific Officer, BRAVO
36 18 VICTOR. Email: renata.gomes@bravovictor.org
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41 20 **Keywords:** telerehabilitation; rehabilitation; vision impairment
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3 22 **ABSTRACT**
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5 23 **Objective:** To describe the nature of telerehabilitation services available to people
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7 24 with vision impairment and summarise available evidence relating to effectiveness.
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9 25 **Design:** Systematic review.
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11 26 **Data sources:** CINAHL Plus, MEDLINE, PsycARTICLES, PsychINFO, Embase,
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13 27 PubMed, HMIC and Ovid Emcare were searched, without date restrictions up to 24
14
15 28 May 2021. A detailed search of online grey literature was also conducted.
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17 29 **Eligibility criteria:** Eligible studies evaluated effectiveness of telerehabilitation
18
19 30 services for visually impaired people. Studies were excluded if they did not relate to
20
21 31 remote service delivery, were not available in English, or focused on distance learning
22
23 32 of visually impaired students.
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25 33 **Data extraction and synthesis:** Two independent reviewers screened articles and
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27 34 extracted data. A risk of bias analysis was performed.
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29 35 **Outcome measures:** Measures of effectiveness included performance-based
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31 36 assessment, patient-reported outcomes, and cost-effectiveness.
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33 37 **Results:** Of 4,472 articles, 10 eligible studies were included. Four studies (33.3%)
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35 38 addressed patient satisfaction and recommendations, two studies (16.6%) related to
36
37 39 vision training, four studies (33.3%) measured patient-reported outcomes and well-
38
39 40 being, one study (8.3%) addressed managing clinical symptoms and one study (8.3%)
40
41 41 analysed cost-effectiveness. Two studies featured across multiple domains.
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42 42 **Conclusion:** Publication trends suggest telerehabilitation is increasingly featuring in
43
44 43 the low vision rehabilitation care pathway. Patients are generally accepting of this
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46 44 model and may benefit from improved functional and quality-of-life outcomes. This
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48 45 systematic review highlights that further trials are needed to evaluate telerehabilitation
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46 46 using a robust set of outcome measures.
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51 47 **PROSPERO registration number:** CRD42021254825
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3 50 **Strengths and limitations of this study**
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- 6 52 • This review provides novel findings informing design of future trials and
7 53 evaluations of telerehabilitation.
8 54 • Inclusion of grey literature reduces publication bias and increases the
9 55 comprehensiveness of the review.
10 56 • Only articles written in English were included and results were seldom
11 57 disaggregated by disease type or severity.
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60 INTRODUCTION

61 Visual impairment is a broad term used to describe a reduction in visual sensitivity that
62 cannot be corrected by standard eyeglasses or medical treatment. It is estimated that
63 over 2 million people in the United Kingdom (UK) are living with a form of visual
64 impairment ⁽¹⁾. Visually impaired individuals may be classified as 'sight impaired' (i.e.,
65 partially sighted) or 'severely sight impaired' (i.e., legally blind) ⁽²⁾. The impact of visual
66 impairment can be complex and highly heterogenous, affecting aspects of daily
67 functioning, mobility, and quality of life ⁽³⁻⁸⁾. Among the widely prevalent ophthalmic
68 conditions such as age-related macular degeneration, glaucoma, and diabetic
69 retinopathy, loss of vision is typically progressive and irreversible; hence, support
70 heavily relies on rehabilitation to promote adaption, enabling patients to better manage
71 the challenges associated with vision loss and to live an independent and fulfilling life
72 ^(9, 10).

73 The mainstay of rehabilitation is to restore or maintain physical and/or
74 psychological functioning to the maximum degree possible in individuals living with
75 disease or injury. In vision rehabilitation, eye care providers are encouraged to provide
76 rehabilitative support or refer patients to relevant services, even in cases of mild or
77 moderate sight loss ⁽¹¹⁾. Rehabilitation encompasses many disciplines, and
78 interventions may include provision of visual aids, devices and software, behavioural
79 training, home environment assessments and adaptations, social and psychological
80 support, leisure and vocational activities, or a combination of these strategies ^(12, 13).
81 However, rehabilitation is characteristically structured around overcoming the practical
82 and functional challenges of sight loss, whilst psychological outcomes are seldom
83 addressed directly ⁽¹⁴⁾. The type of services which are offered often depends on the
84 nature of the visual impairment. For example, the rehabilitative needs of individuals
85 with central visual field loss may differ from those with impaired peripheral vision ⁽¹⁵⁾.
86 The traditional mode of delivery for vision rehabilitation has been in face-to-face
87 settings within outpatient clinics or home visits by low vision specialists or allied health
88 professionals; though digital developments have increased opportunity for remote
89 service delivery (i.e., telerehabilitation).

90 Telerehabilitation, also known as virtual training or e-learning, refers to
91 delivering rehabilitative services using a remote or virtual approach, facilitated by
92 telecommunication technologies. Services may comprise a range of elements

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3 93 designed to assess, prevent, treat, educate, or counsel individuals living with chronic
4 health conditions ⁽¹⁶⁾. Telerehabilitation services may be synchronous, whereby
5 94 services are delivered in real-time using two-way video or audio communication, or
6 95 asynchronous, such as remote evaluation of recorded videos or other measurements
7 96 such as surveys or psychophysical testing ⁽¹⁷⁾. Compared to traditional face-to-face
8 97 rehabilitation, telerehabilitation offers potential benefits, such as reduced costs,
9 98 increased geographical accessibility, and creating opportunities to extend limited
10 99 resources ⁽¹⁸⁾. Moreover, telerehabilitation has been identified as an effective means
11 100 of delivering support to individuals with chronic conditions including multiple sclerosis,
12 101 osteoarthritis, and stroke ⁽¹⁹⁻²¹⁾.
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21 103 Whilst there is convincing evidence to suggest telerehabilitation can be effective
22 104 at improving physical and psychological functioning in people living with chronic health
23 105 conditions, less is known about the effectiveness of telerehabilitation services for
24 106 people with a vision impairment. For example, a previous review sought to compare
25 107 outcomes between face-to-face and virtual vision rehabilitation services, yet no
26 108 completed studies in this area were found ⁽²²⁾. Additionally, new services emerging
27 109 during the COVID-19 pandemic have yet to be reviewed. This is significant given the
28 110 rapid and extensive scale-up of telehealth services since the beginning of the
29 111 pandemic ^(23, 24). This systematic review, therefore, aims to draw together evidence on
30 112 telerehabilitation services, and describe their impact on health and well-being
31 113 outcomes in people with vision impairment.
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44 115 **Objectives**

- 45 116 1. Describe the nature of telerehabilitation services available to people with vision
46 117 impairment.
- 47 118 2. Collect and summarise evidence on the impact of telerehabilitation in terms of
48 119 health-related outcomes, well-being and cost-effectiveness.

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3 **123 METHODS**
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5 124 This review follows best practice for conducting systematic reviews as outlined by the
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7 125 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)
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9 126 checklist to ensure all aspects of the process are undertaken using rigorous and
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11 127 transparent methods ^(25, 26). A search of the electronic databases CINAHL Plus and
12
13 128 MEDLINE (via EBSCOhost) and PsycARTICLES, PsychINFO, Embase, PubMed,
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15 129 HMIC and Ovid Emcare (via Ovid) was undertaken. As recommended by The
16
17 130 Cochrane Handbook for Systematic Reviews of Interventions, medical subject
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19 131 headings (MeSH) were used to identify the most relevant articles ⁽²⁷⁾. MeSH terms are
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21 132 official words or phrases selected to represent medical concepts and are assigned to
22
23 133 articles in order to describe what the research item is about ⁽²⁸⁾. This process provided
24
25 134 a list of keywords relating to vision impairment and telerehabilitation. For detailed
26
27 135 search terms, see Table 1. Reference lists of included studies and any identified
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29 136 systematic reviews were also reviewed for relevant articles, and citation tracking was
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31 137 performed using Google Scholar.
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Vision impairment term		Telerehabilitation term
vision OR low vision OR vision loss OR reduced vision OR subnormal vision OR diminished vision OR vis* impair* OR sight loss OR blind* OR partially sighted	AND	telerehab* OR tele-rehab* OR remote rehab* OR virtual rehab* OR e-learning OR online learning OR online training OR telephone training OR telephone rehab* OR telephone learning OR virtual learning OR web training OR virtual training

Table 1. Search terms

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140 In addition, we reviewed online conference proceedings for relevant abstracts. A
141 search of grey literature included searching for relevant articles or reports on the
142 websites of organisations such as the UK National Institute for Health and Clinical
143 Excellence (NICE; www.nice.org.uk) and National Health Service (NHS) Evidence
144 (www.evidence.nhs.uk). We also conducted an extensive search of the UK Charity
145 Commission website to identify organisations with links to vision impairment and
146 rehabilitation. Relevant charity websites were then searched and in cases where
147 telerehabilitation was documented, any available documentation was downloaded and

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3 148 reviewed, and charities were contacted to enquire about the current status of
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5 149 telerehabilitation.

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7 150 Articles written in English, with no restrictions on publication period, and only where
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9 151 the full text was available were included. Studies were further required to address the
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11 152 exposure of interest (i.e., visual impairment and telerehabilitation). Articles were
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13 153 excluded if they did not relate to remote service delivery (i.e., face-to-face services).
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15 154 Articles focusing only on an educational context were also excluded. For example,
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17 155 visually impaired students using home technology for distance learning.

18 156 Two authors (LJ and ML) independently screened studies using Covidence systematic
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20 157 review software (Veritas Health Innovation Ltd, Melbourne, Australia; available
21
22 158 at www.covidence.org) to assess eligibility. Any disagreement in coding decisions
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24 159 were resolved through discussion. Relevant information (e.g., publication details,
25
26 160 characteristics of participants, study design, outcomes measured, study results, and
27
28 161 conclusions) from eligible articles was entered into a data extraction table.

29 162 Studies were assessed for quality using Kmet *et al.* 'Standard Quality Assessment
30
31 163 Criteria for Evaluating Primary Research Papers from a Variety of Fields' ⁽²⁹⁾. This
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33 164 quality appraisal tool was chosen because of both quantitative and qualitative studies
34
35 165 emerging from the literature search. This review is registered online with the
36
37 166 International prospective register of systematic reviews (PROSPERO;
38
39 167 www.crd.york.ac.uk/prospero/; Reference CRD42021254825).

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41 169 **Patient and public involvement**

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44 170 No patients were involved in the design of the review. We will disseminate plain
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46 171 language summaries to relevant patient groups including members of Blind Veterans
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50 51 174 **Research ethics approval**

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54 175 Ethical approval for this systematic review was not required.

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177 RESULTS

178 Searches were run on 24 May 2021 and yielded 4,472 results. Of these, 658 were
179 automatically removed as duplicates. This left 3,814 studies to screen using title and
180 abstract, of which 3,719 were excluded and 95 were assessed for full-text eligibility.
181 Studies were mostly excluded at the title and abstract screening stage because they
182 did not relate to telerehabilitation or did not involve visually impaired individuals. These
183 two reasons were also the primary cause for exclusion at the full-text review
184 accounting for 17 and 38 exclusions, respectively. A further two studies were added
185 through reference list searching. Ultimately, 10 full-text studies were selected for
186 inclusion. The study selection process is shown in the PRISMA diagram in Figure 1.

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188 <Insert Figure 1 here>

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190 **Figure 1.** PRISMA diagram showing study selection process. Key: VI = vision impairment

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192 Quality appraisal was conducted on all 10 studies. The lowest score was 0.64, the
193 highest was 1.00 (i.e., all responses to relevant questions in the Kmet *et al.* appraisal
194 criteria were 'Yes'), and the median score was 0.93. The most frequent issues with the
195 studies were the presence of only a partial description of subject characteristics (2 of
196 10) and study conclusions not being fully supported by the data (3 of 10); however,
197 this was the case for just a small proportion of the studies.

198 The following overview of study findings is organised according to the main
199 outcome domains for each of the 10 articles identified in the systematic literature
200 search. Two articles feature in more than one section as the outcomes were
201 translatable across multiple domains. Four studies (33.3%) addressed patient
202 satisfaction and recommendations, two studies (16.6%) related to vision training, four
203 studies (33.3%) measured patient-reported outcomes and well-being, one study
204 (8.3%) addressed managing clinical symptoms and a further one study (8.3%) was an
205 analysis of cost-effectiveness. For full details of the included studies, refer to the data
206 extraction table (Supplementary material).

Patient satisfaction and recommendations

Four articles explored patients' satisfaction with telerehabilitation and recommendations for key features to improve uptake of services. Three of these articles reported the findings of feasibility studies and one was a qualitative analysis of patient experiences. All of these studies included participants with a visual impairment caused by a range of pathologies including age-related macular degeneration, optic nerve disease, retinitis pigmentosa, and stroke-related visual field deficit.

Dunne *et al.*'s ⁽³⁰⁾ study of stroke survivors reports the outcomes of qualitative interviews and focus groups with patients and carers. The study was informed by the findings of a survey of Stroke Association group members in the UK and the aims were to understand experiences of a compensatory eye-movement tool and training packages. The Durham Reading and Exploration Training (DREX) is a computer-based telerehabilitation training system teaching adaptive eye movement strategies to enable stroke survivors to cope more effectively with visual field deficits. DREX is a mobile application which incorporates tasks that combine both reading and exploration (e.g., scanning an array to locate a target). The wider study required patients with stroke-related visual field defects to complete the DREX trials on a tablet in their own homes and outcomes were compared to a control intervention, which consisted of attention-based tasks with no eye movement or exploration exercises. Significantly greater gains were observed in performance, visual functioning and everyday behaviours following DREX than the control intervention ⁽³¹⁾. Qualitative responses highlighted a range of issues in the application of telerehabilitation for visually impaired stroke survivors. For example, a lack of confidence with technology, perceived fear of making mistakes while online, distrust of the quality of the intervention, and concerns with reduced face-to-face contact. However, these issues could be addressed in initial in-person visits to alleviate concerns and facilitate engagement and motivation in the rehabilitation process. One challenge is that compensatory training is inherently repetitive in nature; thus, measures should be taken to ensure telerehabilitation tools remain accessible to avoid disengagement. The authors propose one approach which may obviate disengagement is to employ feedback and goal setting to improve motivation and provide tangible progress updates.

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3 Patient satisfaction was assessed by Bittner *et al.* ⁽³²⁾ in a pilot study to develop,
4 administer and evaluate a synchronous virtual low vision portal providing
5 telerehabilitation services. Ten patients diagnosed with either age-related macular
6 degeneration (n = 9) or diabetic retinopathy (n = 1) were enrolled. Participants were
7 required to have access to a home telephone to use the Internet-based video
8 conference portal. Tablet devices were provided as well as MiFi (wireless router which
9 acts as a mobile Wi-Fi hotspot) to enable connection to the Internet. Each participant
10 received one telerehabilitation session which lasted approximately one hour. The
11 session included administration of the MNREAD chart which consists of a series of
12 60-character sentences displayed over three lines and is used to assess reading
13 fluency and proficiency using optical magnifiers, using video and audio recordings of
14 the participant. Assessments of working distance and lighting were made by the
15 provider viewing the video of the participant reading with their magnifier, whereas
16 assessments of reading speed and accuracy relied on the audio component as
17 participants read aloud during the MNREAD and near acuity tests. The outcomes
18 were participants' and providers' audio and video quality ratings. Video quality was
19 rated as excellent to good, whereas audio ratings were more variable. All participants
20 were satisfied and comfortable receiving telerehabilitation and evaluation via
21 videoconferencing. Eight of 10 reported that their magnifier use improved after
22 telerehabilitation. All except one reported that they were very interested in receiving
23 telerehabilitation services again if their visual needs changed.

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40 Lorenzini and Wittich report outcomes related to patient satisfaction in a
41 feasibility study using a head-mounted video platform to deliver synchronous
42 telerehabilitation sessions at home ⁽³³⁾. Participants received real-time distance
43 training sessions delivered by a low vision therapist. The intervention focused on the
44 technical aspects of using eSight eyewear, an assistive technology designed to
45 maximise visual input and compensate for vision loss. The intervention group
46 underwent a personalised training programme including eSkills functional learning
47 activities such as reading, writing, and distance vision training. A control group were
48 allocated to conventional eSight self-training using the eSkills user guide. Fifty-seven
49 visually impaired participants were enrolled (experimental group, n = 28), the most
50 common causes of sight loss were optic nerve disease, age-related macular
51 degeneration, retinopathy of prematurity, and retinitis pigmentosa. Retention rates
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3 during the study were 93% (n = 53) at 2 weeks, 68% (n = 39) at 3 months, and 65%
4 (n = 37) at 6 months. A higher proportion of patients who withdrew from the study were
5 enrolled into the control group. Participants reported being comfortable with receiving
6 telerehabilitation training at home, with 16 of 23 (66%) agreeing the programme was
7 effective and efficient, and the majority (20 of 23) approving that they would be
8 interested in using telerehabilitation again in the future.
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14 A parallel investigation by Lorenzini and Wittich used standardised measures
15 to assess quality of life and patient satisfaction following the eSight telerehabilitation
16 programme ⁽³⁴⁾. Quality of life outcomes are reported in a later section. Satisfaction
17 was measured using the 12-item Quebec User Evaluation of Satisfaction with
18 Assistive Technology (QUEST) tool. Scores on the measure increased for participants
19 in both the experimental and control group between baseline and 3-months of device
20 usage, suggesting satisfaction improved independently of the type of training. There
21 were no differences in assistive technology-related satisfaction based on age or sex.
22 Improvement in QUEST scores were not maintained at 6-months. The authors suggest
23 this may be due to the device no longer meeting certain needs after extended usage,
24 or a lessening impact of social desirability, leading to more realistic and honest
25 responses from participants over time.
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37 ***Vision training***

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39 Two studies focused on training related to optimisation of vision delivered through a
40 telerehabilitation service. Both studies included patients with measurable visual field
41 loss including areas of diminished sensitivity in glaucoma and hemianopia in stroke
42 patients.
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47 Sabel and Gudlin compared outcomes of behavioural training using a 1-hour
48 computer-based vision restoration programme for people with glaucoma and a
49 placebo group ⁽³⁵⁾. Participants were required to have a stable glaucomatous visual
50 field defect inside 30° eccentricity in at least one eye, with well controlled intraocular
51 pressure. After baseline assessments, training was performed 6-days per week for 3-
52 months at home on a commercially available computer with adaptive parameter
53 adjustments. The experimental group performed vision training similar to perimetry
54 whereby visual stimuli of varying luminance are presented in areas of residual vision.
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3 The placebo group performed stimulus discrimination training. Vision restoration
4 exercises led to improved vision-related performance (detection accuracy and faster
5 reaction time) without affecting eye movements. The authors conclude that visual
6 system plasticity can be retained into older age despite widespread visual deterioration
7 and activation of residual vision may partly reverse vision loss.
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12 A study on patients with hemianopia used a bespoke asynchronous audio-
13 visual telerehabilitation system ⁽³⁶⁾. The system featured a semi-circular apparatus in
14 which visual and acoustic stimuli are presented and a central camera to control head
15 and eye movements. Patients used the system at home on a customised tablet which
16 was controlled by a hospital-based therapist. Following an initial assessment in the
17 clinic, participants underwent training at home at least 5 days a week for up to 12
18 months. The aim of the training was to stimulate multisensory integration mechanisms
19 to reinforce visual and spatial compensatory functions, for example, adoption of
20 oculomotor strategies. Among the sample of three adults with hemianopia, all were
21 capable of actively using the device independently whilst under remote supervision
22 and showed improvements in visual detection abilities over the study period. The
23 authors conclude that the device may contribute to better visual outcomes and could
24 be used to reduce the need for one-to-one hospital visits.
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37 ***Quality-of-life and well-being***

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39 Four articles assessed outcomes relating to quality-of-life and well-being following
40 telerehabilitation. The studies use patient-reported outcome measures and
41 behavioural measurements to examine the effectiveness of remote interventions in
42 people with a vision impairment. Two articles are case reports, and two articles
43 describe the quality-of-life outcomes from the eSight eyewear and vision restoration
44 training programmes described in an earlier section.
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51 Lorenzini and Wittich ⁽³⁴⁾ measure changes in quality-of-life following
52 telerehabilitation with the eSight eyewear programme using the Psychosocial Impact
53 of Assistive Devices Scale (PIADS), a 26-item questionnaire composed of three
54 subscales (competence, adaptability, and self-esteem), and the Veterans Affairs Low
55 Vision Visual Functioning Questionnaire (VA LV VFQ-48), a 48-item instrument used
56 to measure outcomes of patients receiving low vision rehabilitation. Visually impaired
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3 participants completed the measures at baseline, 2-weeks, 3-months, and 6-months.
4 Results patterns were similar across the three subscales of the PIADS showing
5 statistically significantly improved scores after 3 months in both the intervention and
6 control groups, indicating that assistive technology-related quality-of-life (i.e.,
7 perceived impact of assistive devices on quality-of-life) improved independently of the
8 type of training received. Self-reported functional vision outcomes, as determined by
9 the VA LV VFQ-48, yielded statistically significant improvements in overall scores, as
10 well as in all subscales (reading, visual information, mobility, visual motor) after 2
11 weeks of using the device; improvements also continued after 3 months.

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19 Sabel and Gudlin's ⁽³⁵⁾ vision restoration programme used the National Eye
20 Institute Visual Function Questionnaire (NEI-VFQ-25) and the Short-Form-36 (SF-36)
21 to measure changes in quality of life between baseline and post-intervention follow-
22 up. Vision training was not associated with robust changes on these measures. Only
23 the mental health subscale of the SF-36 was found to have improved, which may be
24 caused by non-specific training effects such as attention, alertness, or expectation.
25 However, participants had generally scored highly on both measures at baseline,
26 indicating few everyday vision deficits.

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33 A case report by Dogru-Huzmeli *et al.* ⁽³⁷⁾ explored whether diplopia complaints
34 could be ameliorated using the Cawthorne-Cooksey exercises applied via
35 telerehabilitation in a multiple sclerosis patient with a visual field scotoma. Cawthorne-
36 Cooksey exercises use a set of eye and head movements which are based on the
37 concept of habituation and designed to build up a tolerance mechanism to support
38 equilibrium and balance. Exercises were delivered through WhatsApp video calls over
39 30 sessions. Comparison of pre- and post- eye examinations suggested gaze
40 restriction had improved and that the patient had fewer double vision complaints. Pre-
41 and post-intervention quality-of-life was assessed using the SF-36 measure of general
42 health. The authors report improvement in all domains of the SF-36, except for
43 physical functioning, where there was no change.

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53 A study from Lancioni and colleagues assessed whether two congenitally blind
54 women could be supported to make independent phone calls using a computer-aided
55 system ⁽³⁸⁾. Both women attended a rehabilitation centre where the study took place.
56 The system comprised of a netbook computer which was enabled with a global system
57 for mobile communication with a headset and microphone apparatus. The study
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3 adopted an ABAB design in which A represented baseline phases and B represented
4 intervention phases with the telephone system. Communication-related outcomes
5 included the total number of calls made, number of calls met with a response, and
6 length of calls. Both participants learnt to use the system and made phone calls
7 independently to a variety of contacts such as family members, friends, and care staff
8 personnel, indicating that the intervention may be useful for enabling people with a
9 vision impairment to manage phone calls on their own.
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18 ***Managing symptoms***

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20 One study used a telerehabilitation approach to support patients attending a
21 residential school for visually impaired people during the COVID-19 pandemic. Senjam
22 and colleagues⁽³⁹⁾ used voice-over internet protocols (e.g., WhatsApp calling, Zoom)
23 to enable a rehabilitation team to deliver education and counselling interventions and
24 monitor ocular complaints among visually impaired adults and children. Over a 2-
25 month study period, 492 patients contacted the team. Health-related complaints were
26 made by 335 patients, the most common ocular complaints being itching (36.1%),
27 watering (16.1%), and painful eyes (3.6%). Counselling sessions addressed
28 uncertainty surrounding clinical monitoring of eye health. The study suggests that
29 preventative strategies to help manage ocular symptoms could be delivered through
30 telerehabilitation, although the outcome of interventions was not known.
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42 ***Cost-effectiveness***

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44 A retrospective cost analysis from Ihrig⁽⁴⁰⁾ examined the economic practicality of a
45 clinical model of telerehabilitation for visually impaired military veterans.
46 Telerehabilitation was delivered by an optometrist and rehabilitation therapist to
47 veterans with conditions including age-related macular degeneration, glaucoma,
48 diabetic retinopathy, cataracts, and retinitis pigmentosa. Sessions took place remotely
49 at either the participants' home or local community outpatient centre. Total and median
50 travel cost and time savings were estimated per veteran per fiscal year. Introduction
51 of the telerehabilitation service in 2012 increased access to rural veterans in Western
52 New York. Over a 5-year period, 419 veterans who were unable to access traditional
53 low vision rehabilitation due to travel issues accessed the remote service. The
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3 proportion of patients accessing the telerehabilitation service represented 24% of the
4 overall rehabilitation caseload. Median saving of travel miles was 122 miles per
5 veteran (51,136 miles/419 veterans). Median saving of travel time was 2.09 hours per
6 veteran (878 hours/419 veterans). Overall, median travel cost saving per rural
7 individual was \$65.29 per veteran (\$27,357.76/419 veterans). The authors conclude
8 that telerehabilitation can be a practical, time-saving, and cost-saving alternative to
9 traditional face-to-face consultations.
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18 ***Grey literature***

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20 Searches of charity websites led to the identification of 11 organisations in the UK
21 where vision rehabilitation services had been shifted to remote delivery. The charities
22 were contacted about the nature of services and whether any evaluations had been
23 undertaken. This process resulted in the review of seven documents, predominantly
24 internal reports about the restructure of rehabilitation services during the COVID-19
25 pandemic. While these documents were mostly descriptive, there was useful
26 information demonstrating telerehabilitation practice patterns in the third sector. For
27 example, Blind Veterans UK, a charity providing support and services to visually
28 impaired UK veterans, reported information about the needs of their beneficiaries,
29 experimental methods in delivering remote rehabilitation, and working with allied
30 agencies throughout the COVID-19 pandemic to signpost members to support.
31 Similarly, charities such as Royal National Institute of Blind People and National
32 Federation of the Blind describe telerehabilitation frameworks which have been
33 implemented during the pandemic.
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48 ***Trends in publishing***

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50 There has been an increase over time in published studies evaluating the impact of
51 telerehabilitation on people with a vision impairment. Yet, these studies represent only
52 a small proportion of the total research on people with vision impairment. For example,
53 a PubMed search for articles with 'vision impairment' or 'blindness' in the title or
54 abstract yields 17,783 results since 2010 alone; while in that same period just 10
55 articles (0.06%) were published that were relevant to telerehabilitation and were
56 included in this review.
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Discussion

Vision rehabilitation is a key stage in the eye care journey. Rehabilitative services can help to mitigate the impact of vision loss by equipping patients with new skills and training while providing social connectedness and psychological support⁽⁴¹⁻⁴⁵⁾. This review shows that the landscape of rehabilitation is evolving to include synchronous and asynchronous approaches to remote rehabilitation for people with sight loss conditions. Studies using patient-reported outcome measures suggest telerehabilitation can lead to improved outcomes relating to daily functioning and quality-of-life. In addition, there is generally a high level of acceptability from patients for this shift in service delivery. However, there remain certain distinct challenges associated with telerehabilitation which may curtail the extent to which this approach is adopted and retained more widely.

Several of the studies in this review included recommendations for telerehabilitation which provide helpful insights. For example, a period of direct training with home-based technology was regarded positively, suggesting such training can provide patients with a helpful rehabilitation framework. Despite an increasing number of visually impaired adults engaging with technology⁽⁴⁶⁾, it is inevitable that some individuals will have underlying concerns about their technical readiness to operate devices at home. An assessment of individual self-efficacy regarding health management and aptitude for telerehabilitation may, therefore, help to prioritise individuals for whom this approach is most likely to be tolerated and successful.

A key challenge associated with telerehabilitation is maintaining patient motivation and engagement. Rehabilitation is, by nature, highly repetitive and often requires continuous engagement over long periods of time before measurable effects can be observed. Although studies in this review yielded good patient satisfaction ratings⁽³⁴⁾ and high retention rates⁽³³⁾, it is difficult to predict the sustainability of telerehabilitation outside the context of a research study. For example, devices risk becoming a nuisance if required long term, and whilst acceptable within research, patients may resist such commitments becoming the standard of care⁽⁴⁷⁾. Studies in this review described intensive programmes of telerehabilitation, in some instances requiring several hours of engagement per week. Further research using real-world data on patterns of engagement with telerehabilitation will be a valuable addition to

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3 the literature and could help to identify factors associated with adherence and
4 withdrawal, and behavioural strategies to encourage adoption.
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7 One aspect of telerehabilitation which increases its appeal is the potential for
8 substantial direct and indirect cost savings. The 2019 study by Ihrig⁽⁴⁰⁾ highlighted that
9 telerehabilitation was associated with considerable time and cost savings for patients
10 by reducing travel requirements and fuel consumption. However, in cases where
11 individual specialist equipment was required, such as the adapted telephone system
12 in the study from Lancioni and colleagues⁽³⁸⁾, costs per unit were expected to be in
13 the region of \$2,000 USD. The economic value of telerehabilitation from a provider
14 perspective requires more research. For example, additional costs may be incurred
15 for services such as training, measurement readings, data management, and ongoing
16 maintenance of many devices. Indeed, remote service delivery has been associated
17 with slightly higher costs to service providers, such as speech therapy in people with
18 Parkinson's disease⁽⁴⁸⁾. Nevertheless, it could be expected that remote rehabilitation
19 costs would be largely absorbed by the reduced need for time and resources required
20 for non-remote services. It is noteworthy that telerehabilitation may have a wider reach
21 than standard rehabilitation services, and the increased availability and convenience
22 of a remote service may be more appealing to a broader profile of patients (e.g.,
23 working age individuals with minimal time for in-person sessions). As shown by Ihrig
24⁽⁴⁰⁾, remote service delivery led to an average workload increase of 24% due to a
25 higher number of patents accessing the service. If this finding applied to a broader
26 audience, there will likely be a larger rehabilitation patient caseload, with possible
27 capacity implications for clinical practice.
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44 One difficulty associated with comparing results across studies is the lack of
45 consensus when measuring outcomes. Across all ten studies identified in this review,
46 27 different outcome measures were used to assess the effectiveness of
47 telerehabilitation. These included both performance-based assessments, such as
48 psychometric testing, and subjective or patient-reported measures of health status,
49 visual functioning and quality of life. In the four studies which used patient-reported
50 outcomes, just one measure (SF-36) was used in more than one study. An important
51 consideration for clinicians, researchers and trialists could be to aim for a more unified
52 approach when deciding on a core set of outcome measures in future trials and
53 evaluations of telerehabilitation. Secondly, whilst it is encouraging that patients' views
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3 and experiences are being considered when measuring the effectiveness of
4 telerehabilitation, it is important to consider the sensitivity of outcome measures to
5 meaningful changes in areas such as functionality, symptomatology, and quality-of-
6 life etc. For example, the non-significant changes in quality-of-life observed in the
7 study by Sabel and Gudlin ⁽³⁵⁾ could be explained by the use of non-disease-specific
8 measures, which may not be sufficiently sensitive to detect small or subtle changes in
9 visual function ⁽⁴⁹⁾. Finally, the evidence synthesised in this review suggests that
10 telerehabilitation is generally regarded as acceptable by those who are willing to
11 engage with it. Yet, acceptability is a multifaceted concept which may not be fully
12 explained by behaviour such as the degree of adherence or engagement with an
13 intervention; thus, future studies investigating acceptability may benefit from a
14 theoretical framework to guide the assessment of acceptability ⁽⁵⁰⁾.

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16 Although no studies were formally excluded on the basis of insufficient quality,
17 some common study limitations were identified. The majority of the studies introduce
18 a self-selection bias when participants elect to take part in research and are
19 willing/show willingness to engage with telerehabilitation programmes. Although
20 common in cross-sectional research, self-selection bias can complicate the
21 interpretation of study data as participants' propensity for participating in research may
22 correlate with the topic under investigation. For example, Lorenzini and Wittich ⁽³³⁾
23 report that 79% of eligible participants declined to take part in the study. As such, the
24 conclusions are based on a relatively small proportion of the target population.
25 Reasons for non-participation were seldom discussed in the published reports;
26 therefore, it is unclear whether factors such as level of familiarity with devices, visual
27 functioning, extent of sight loss, or having assistance from a normally sighted friend or
28 family member impact on engagement with telerehabilitation. In addition, study
29 findings to date have evaluated telerehabilitation over a relatively short period of time.
30 As observed by Lorenzini and Wittich ⁽³³⁾, engagement is more likely to decrease after
31 6 months, highlighting the need for more longitudinal studies. A further common
32 limitation was the relatively small sample sizes observed in the studies. For example,
33 four of the 10 studies included in this review had a sample size of 10 or fewer. There
34 are currently very few randomised controlled clinical trials evaluating patient outcomes
35 in telerehabilitation, and we propose this would be an important avenue for further
36 research.

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3 This review's methodology has a number of limitations. Only articles written in
4 English were screened and ultimately included, thus excluding potentially relevant
5 studies in languages other than English. However, only three studies were excluded
6 for this reason. Moreover, included studies were required to relate to some form of
7 vision impairment, and several studies included heterogenous samples of varying or
8 unknown degrees of sight loss from numerous conditions. A range of vision
9 impairment terms were used across the studies including 'sight loss', 'blindness' and
10 "low vision". Results were rarely disaggregated by disease severity or type, thereby
11 making it difficult to account for potential nuances between different patient groups
12 under the broad overarching term of 'vision impairment'. A key strength of this review
13 was the inclusion of grey literature. Grey literature includes a range of documents not
14 controlled by commercial publishing organisations and can be a rich source of
15 information which cannot be obtained from other sources ⁽⁵¹⁾. Our analysis of grey
16 literature showed that after an initial switch to remote service delivery during the
17 COVID-19 pandemic, many charities were reviewing their long-term rehabilitation
18 frameworks with an indication that pathways will include a blended approach, offering
19 both remote and face-to-face services on a personalised basis, but require further
20 auditing and evaluation. It is notable that besides a few national sight loss charities
21 (Blind Veterans UK, RNIB), the availability of telerehabilitation appeared to vary
22 greatly, with availability appearing highest within local charities in areas including
23 Cambridgeshire, Leicestershire, and Nottinghamshire. While a paucity of online
24 documentation in other regions does not necessarily equate to an absence of such
25 services, it does suggest a possible unevenness in their availability across local
26 authorities. This may reflect broader issues pertaining to unequal access to sight loss
27 support nationwide. As telerehabilitation continues to emerge as an effective and
28 potentially permanent fixture in the care pathways of visually impaired people, there is
29 a need to bridge the gaps in service delivery to ensure there is equitable provision
30 across all areas of the UK, particularly given the potential for a wider geographical
31 reach with remote services thereby increasing access to support.

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34 In summary, the COVID-19 pandemic necessitated a redesign of traditional
35 face-to-face rehabilitation pathways to remote service delivery. A previous systematic
36 review assessing the effectiveness of low vision telerehabilitation found no studies had
37 been completed in this area ⁽²²⁾. We identified a range of remote-based rehabilitation
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3 services aimed at optimising vision and encouraging adjustment to sight loss, with
4 evidence to suggest some patients are generally accepting of this model and may
5 benefit from improved functional and quality-of-life outcomes, whilst potentially offering
6 a more cost-effective approach to continuing care. The weight of the evidence
7 suggests telerehabilitation has a promising role in patient care pathways for people
8 with a vision impairment; however, issues around long-term desirability and
9 compliance remain unclear. Given the variability in patients' aptitude and motivation
10 to sustainably engage with telerehabilitation, a self-select approach may be the most
11 practical means of ensuring effective implementation of remote services. This review
12 has addressed increasingly relevant questions about the role of telerehabilitation when
13 applied among visually impaired people. The findings to date begin to illustrate the
14 effectiveness of remote rehabilitation services, but more research is needed to better
15 understand its scalability and longevity. Ultimately, we hope this review can inform key
16 stakeholders, including hospital eye services, community groups, and charities about
17 priority areas for future research and development.

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32 **Author contributions:** All authors made substantial contributions to the design and
33 analysis of the work. LJ and ML performed the literature search, article screening, data
34 extraction, quality appraisal and manuscript preparation. CLC, NH, and RSMG
35 conceptualised the review and edited the manuscript. All authors approved the final
36 manuscript.

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41 **Competing interests:** None

42
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44 TP-211.

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47 **Data availability statement:** No data are available.

References

1. Pezzullo L, Streatfeild J, Simkiss P, Shickle D. The economic impact of sight loss and blindness in the UK adult population. *BMC Health Services Research*, 2018; 18: 63.
2. Royal National Institute of Blind People (RNIB). The criteria for registration. Available at: www.rnib.org.uk/eye-health/registering-your-sight-loss/criteria-certification [Accessed Dec 6 2021].
3. Chiang PP, Zheng Y, Wong TY, Lamoureux EL. Vision impairment and major causes of vision loss impacts on vision-specific functioning independent of socioeconomic factors. *Ophthalmology*, 2013; 120(2): 415-22.
4. Taylor DJ, Hobby AE, Binns AM, Crabb DP. How does age-related macular degeneration affect real-world visual ability and quality of life? A systematic review. *BMJ Open*, 2016; 6(12): p.e011504.
5. Fenwick EK, Ong PG, Man REK, et al. Association of Vision Impairment and Major Eye Diseases With Mobility and Independence in a Chinese Population. *JAMA Ophthalmology*, 2016; 134(10): 1087–1093.
6. Swenor BK, Simonsick EM, Ferrucci L, Newman AB, Rubin S, Wilson V, and Health, Aging and Body Composition Study. Visual impairment and incident mobility limitations: the health, aging and body composition study. *Journal of the American Geriatrics Society*, 2015; 63(1): 46-54.
7. Jones L, Bryan SR, Crabb DP. Gradually then suddenly? Decline in vision-related quality of life as glaucoma worsens. *Journal of Ophthalmology*, 2017; Article ID 1621640, doi.org/10.1155/2017/1621640
8. Langelaan M, De Boer MR, Van Nispen RM, Wouters B, Moll AC, Van Rens GH. Impact of visual impairment on quality of life: a comparison with quality of life in the general population and with other chronic conditions. *Ophthalmic Epidemiology*, 2007; 14(3): 119-26.
9. Burton AE, Gibson JM, Shaw RL. How do older people with sight loss manage their general health? A qualitative study. *Disability and Rehabilitation*, 2016; 5, 38(23): 2277-85.
10. Hinds A, Sinclair A, Park J, Suttie A, Paterson H, Macdonald M. Impact of an interdisciplinary low vision service on the quality of life of low vision patients. *British Journal of Ophthalmology*, 2003; 87(11): 1391-6.
11. Latham K, Macnaughton J. Low vision rehabilitation needs of visually impaired people. *Optometry in Practice*, 2017; 18(2): 103-10.
12. American Academy of Ophthalmology Vision Rehabilitation Committee. Preferred Practice Pattern Guidelines. Vision Rehabilitation for Adults. San Francisco, CA: American Academy of Ophthalmology; 2013: Available at: www.aao.org/ppp
13. van Nispen RM, Virgili G, Hoeben M, Langelaan M, Klevering J, Keunen JE, van Rens GH. Low vision rehabilitation for better quality of life in visually impaired adults. *Cochrane Database of Systematic Reviews*, 2020; (1).

14. Rees G, Ponczek E, Hassell J, Keeffe JE, Lamoureux EL. Psychological outcomes following interventions for people with low vision: a systematic review. *Expert Review of Ophthalmology*, 2010; 5(3): 385-403.
15. Chung ST. Enhancing visual performance for people with central vision loss. *Optometry and vision science: official publication of the American Academy of Optometry*, 2010; 87(4): 276.
16. Brennan D, Tindall L, Theodoros D, Brown J, Campbell M, Christiana D, Smith D, Cason J, Lee A. A blueprint for telerehabilitation guidelines. *International Journal of Telerehabilitation*, 2010; 2(2): 31.
17. Mechanic OJ, Persaud Y, Kimball AB. Telehealth Systems. In: StatPearls. StatPearls Publishing, Treasure Island (FL); 2020. Available at: www.ncbi.nlm.nih.gov/books/NBK459384/. [Accessed Dec 6 2021].
18. McCue M, Fairman A, Pramuka M. Enhancing quality of life through telerehabilitation. *Physical Medicine and Rehabilitation Clinics*, 2010; 21(1): 195-205.
19. Cottrell MA, Galea OA, O'Leary SP, Hill AJ, Russell TG. Real-time telerehabilitation for the treatment of musculoskeletal conditions is effective and comparable to standard practice: a systematic review and meta-analysis. *Clinical Rehabilitation*, 2017; 31: 625–38.
20. Yeroushalmi S, Maloni H, Costello K, Wallin MT. Telemedicine and multiple sclerosis: A comprehensive literature review. *Journal of Telemedicine and Telecare*, 2020; 26(7-8): 400-13.
21. Chen Y, Abel KT, Janecek JT, Chen Y, Zheng K, Cramer SC. Home-based technologies for stroke rehabilitation: A systematic review. *International Journal of Medical Informatics*, 2019; 123: 11-22.
22. Bittner AK, Yoshinaga PD, Wykstra SL, Li T. Telerehabilitation for people with low vision. *Cochrane Database of Systematic Reviews*, 2020; 2.
23. Wosik J, Fudim M, Cameron B, Gellad ZF, Cho A, Phinney D, Curtis S, Roman M, Poon EG, Ferranti J, Katz JN. Telehealth transformation: COVID-19 and the rise of virtual care. *Journal of the American Medical Informatics Association*, 2020; 27(6): 957-62.
24. Koonin LM, Hoots B, Tsang CA, Leroy Z, Farris K, Jolly T, Antall P, McCabe B, Zelis C, Tong I, Harris AM. Trends in the Use of Telehealth During the Emergence of the COVID-19 Pandemic - United States, January-March 2020. *Morbidity and Mortality Weekly Report*, 2020; 69(43), 1595–9. <https://doi.org/10.15585/mmwr.mm6943a3>
25. Moher D, Liberati A, Tetzlaff J, Altman DG, for the PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med*, 2009; 6(7): e1000097.
26. Shamseer L, Moher D, Clarke M, et al. for the PRISMA-P group. Preferred reporting items for systematic review and meta-analysis protocols (PRISMAP) 2015: elaboration and explanation. *British Medical Journal*, 2015; 2: 349.

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27. Higgins JP, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA, eds., 2019. *Cochrane handbook for systematic reviews of interventions*. John Wiley & Sons.
28. Baumann N. How to use the medical subject headings (MeSH). *International Journal of Clinical Practice*, 2016; 70(2): 171-4.
29. Kmet LM, Lee RC, Cook LS. HTA Initiative #13. Standard quality assessment criteria for evaluating primary research papers from a variety of fields. HTA Initiative. 2004. Available at: <https://www.ihe.ca/advanced-search/standard-quality-assessment-criteria-for-evaluating-primary-research-papers-from-a-variety-of-fields>.
30. Dunne S, Close H, Richards N, Ellison A, Lane AR. Maximizing Telerehabilitation for Patients With Visual Loss After Stroke: Interview and Focus Group Study With Stroke Survivors, Carers, and Occupational Therapists. *J Med Internet Res*, 2020; 22(10) :e19604
31. Aimola, L., Lane, A.R., Smith, D.T., Kerkhoff, G., Ford, G.A. and Schenk, T., 2014. Efficacy and feasibility of home-based training for individuals with homonymous visual field defects. *Neurorehabilitation and Neural Repair*, 28(3), pp.207-218.
32. Bittner AK, Yoshinaga P, Bowers A, Shepherd JD, Succar T, Ross NC. Feasibility of telerehabilitation for low vision: satisfaction ratings by providers and patients. *Optometry and Vision Science*, 2018; 95(9): 865-72.
33. Lorenzini, MC, Wittich W. Personalized Telerehabilitation for a Head-mounted Low Vision Aid: A Randomized Feasibility Study. *Optometry and Vision Science*, 2021; 98(6): 570-581.
34. Lorenzini, MC, Wittich, W. Head-mounted Visual Assistive Technology–related Quality of Life Changes after Telerehabilitation. *Optometry and Vision Science*, 2021; 98(6): 582-591
35. Sabel BA, Gudlin J. Vision restoration training for glaucoma: a randomized clinical trial. *JAMA Ophthalmology*, 2014; 132(4): 381-9.
36. Tinelli F, Cioni G, Purpura G. Development and implementation of a new telerehabilitation system for audiovisual stimulation training in hemianopia. *Frontiers in Neurology*, 2017; 8: 621.
37. Dogru-Huzmeli E, Duman T, Cakmak AI, Aksay U. Can diplopia complaint be reduced by telerehabilitation in multiple sclerosis patient during the pandemic?: A case report. *Neurological Sciences*, 2021; 1-4.
38. Lancioni GE, O'Reilly MF, Singh NN, Oliva D. Enabling two women with blindness and additional disabilities to make phone calls independently via a computer-aided telephone system. *Developmental Neurorehabilitation*, 2011; 14(5): 283-9.
39. Senjam SS, Manna S, Vashist P, Gupta V, Varughese S, Tandon R. Tele-rehabilitation for visually challenged students during COVID-19 pandemic: Lesson learned. *Indian Journal of Ophthalmology*, 2021; 69(3): 722.
40. Ihrig C. Travel cost savings and practicality for low-vision telerehabilitation. *Telemedicine and e-Health*, 2019; 25(7): 649-654.

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41. Haymes SA, Johnston AW, Heyes AD. Preliminary investigation of the responsiveness of the Melbourne Low Vision ADL index to low-vision rehabilitation. *Optometry and Vision Science*, 2001; 78(6): 373-80.
 42. Reeves BC, Harper RA, Russell WB. Enhanced low vision rehabilitation for people with age related macular degeneration: a randomised controlled trial. *British Journal of Ophthalmology*, 2004; 88(11): 1443-1449.
 43. Horowitz A, Reinhardt JP, Boerner K. The effect of rehabilitation on depression among visually disabled older adults. *Aging & Mental Health*, 2005; 9(6): 563-70.
 44. Stelmack JA, Szlyk JP, Stelmack TR, Demers-Turco P, Williams RT, Massof RW. Measuring outcomes of vision rehabilitation with the veterans affairs low vision visual functioning questionnaire. *Investigative Ophthalmology & Visual Science*, 2006; 47(8): 3253-61.
 45. Binns AM, Bunce C, Dickinson C, et al. How effective is low vision service provision? A systematic review. *Surv Ophthalmol*, 2012; 57: 34-65.
 46. Ali ZC, Shakir S, Aslam TM. Perceptions and use of technology in older people with ophthalmic conditions. *F1000Res*, 2019; 8:86.
 47. Jones L, Callaghan T, Campbell P, Jones PR, Taylor DJ, Asfaw DS, Edgar DF, Crabb DP. Acceptability of a home-based visual field test (Eyecatcher) for glaucoma home monitoring: a qualitative study of patients' views and experiences. *BMJ Open*, 2021; 11(4): e043130.
 48. Saiyed M, Hill AJ, Russell TG, Theodoros DG, Scuffham P. Cost analysis of home telerehabilitation for speech treatment in people with Parkinson's disease. *Journal of Telemedicine and Telecare*, 2020; 26: 1-6.
 49. Jones L, Garway-Heath DF, Azuara-Blanco A, Crabb DP, Bunce C, Lascaratos G, Amalfitano F, Anand N, Bourne RR, Broadway DC, Cunliffe IA. Are patient self-reported outcome measures sensitive enough to be used as end points in clinical trials?: evidence from the United Kingdom Glaucoma Treatment Study. *Ophthalmology*, 2019; 126(5): 682-9.
 50. Sekhon M, Cartwright M, Francis JJ. Acceptability of healthcare interventions: an overview of reviews and development of a theoretical framework. *BMC Health Services Research*, 2017; 17(1):1-13.
 51. Adams J, Hillier-Brown FC, Moore HJ, et al. Searching and synthesising 'grey literature' and 'grey information' in public health: critical reflections on three case studies. *Syst Rev*, 2016; 5 164.

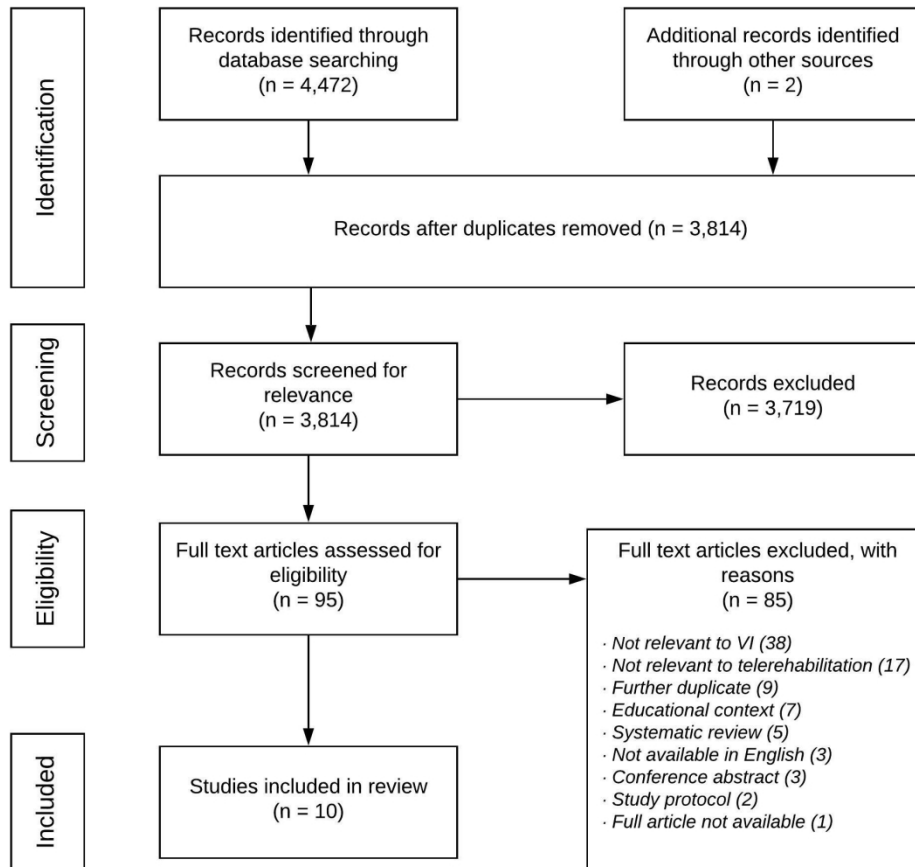


Figure 1. PRISMA diagram showing study selection process. Key: VI = vision impairment

170x159mm (300 x 300 DPI)

Supplementary material – Data extraction table

Authors	Study title	Design	Domain(s) of outcomes	Location	Study objectives	Study populations	Main results/conclusions
Bittner <i>et al.</i> , 2018	Feasibility of telerehabilitation for low vision: satisfaction ratings by providers and patients	Experimental	Patient satisfaction and recommendations	USA	To develop, administer, refine and evaluate components required to deliver follow-up low vision telerehabilitation services.	10 participants with self-rated vision ranging from good to poor. 9 with AMD; 1 with DR. Average age 80 (range = 63-91) years.	Providers and participants rated video quality as excellent to good. Audio quality ratings were variable, generally related to signal strength or technical issues during some sessions. All participants agreed that they were satisfied and comfortable receiving telerehabilitation. Eight of 10 reported that their magnifier use improved. All except one reported that they were very interested in receiving telerehabilitation again. Positive feedback from both participants and providers in this pilot study supports the feasibility, acceptability, and potential value of low vision telerehabilitation.
Dogru-Huzmeli <i>et al.</i> , 2021	Can diplopia complaint be reduced by telerehabilitation in multiple sclerosis patient during the pandemic? A case report	Case report	QoL and well-being	Turkey	To determine the effect of Cawthorne-Cooksey exercises applied via telerehabilitation on eye movements, vision, and quality of life in a multiple sclerosis patient with diplopia.	1 male participant with multiple sclerosis aged 39 years.	Following 4 months of telerehabilitation, the participant stated that his double vision complaints decreased, and his eyes could move more easily. When eye movements were evaluated, outward gaze restriction had improved. There was no change in visual acuity, anterior and posterior segment examinations, and OCT examination. It can be feasible to administer Cawthorne-Cooksey exercises using telerehabilitation to reduce diplopia.
Dunne <i>et al.</i> , 2020	Maximizing telerehabilitation for patients with visual loss after stroke: interview and focus group study with stroke survivors, carers, and	Qualitative	Patient satisfaction and recommendations	UK	To identify barriers and facilitators using rehabilitation tools and elements of good practice in telerehabilitation among stroke survivors.	66 focus group participants. 32 stroke survivors with partial vision loss (18 men; aged 43-83 years, mean age 62.28 years), 10 carers (7 women; 41-75 years, mean age 54.70 years), and 24	Themes identified problems associated with poststroke health care from both patients' and occupational therapists' perspectives that need to be addressed to improve uptake of telerehabilitation. Themes included identifying additional materials or assistance to boost the impact of training packages. Perceptions of technology were considered a barrier

Authors	Study title	Design	Domain(s) of outcomes	Location	Study objectives	Study populations	Main results/conclusions
	occupational therapists					occupational therapists (19 women; 22-45 years, mean age 31.13 years)	by some but a facilitator by others. In addition, 4 key features of telerehabilitation were identified: additional materials, the importance of goal setting, repetition, and feedback.
Ihrig, 2019	Travel cost savings and practicality for low vision telerehabilitation	Cost analysis	Cost-effectiveness	USA	To evaluate patient acceptance and practicality of low vision telerehabilitation.	419 veterans, average age 83 (range = 50-101) years. 406 were male. 208 had diagnosis that resulted in non-correctable or best corrected visual acuity in both eyes up to 20/150 (defined as not legally blind); 149 had non-correctable or best corrected visual acuity in both eyes of 20/200 or worse (defined as legal blindness); 22 had non-correctable peripheral visual field loss in one or both eyes >20 degrees (defined as not legally blind); and 40 had non-correctable peripheral visual field loss in both eyes <20 degrees (defined as legal blindness).	Of the 419 veterans seen since November 2012 (FY 13), the median saving of travel miles for rural patients was 122 miles per veteran (51,136 miles/419 veterans) and the median saving of travel time was 2.09 h per veteran (878 h/419 veterans). Overall, the median saving of the travel cost per rural individual (utilizing \$0.535 per mile) was \$65.29 per veteran (\$27,357.76/419). Travel mileage and time saving resulted in an increase in access to low-vision rehabilitation (24% increase in partially sighted veterans evaluated in 5 years) by reducing the veteran's travel distance, time, and cost. Utilising low vision telerehabilitation increases early access and enables veterans who cannot travel to a specialty clinic the opportunity to prevent potential decline in functional ability over time.
Lancioni <i>et al.</i> , 2011	Enabling two women with blindness and additional disabilities to make phone calls independently via a	Case report	QoL and well-being	Italy	To assess whether two women with blindness and additional disabilities could make independent phone calls through a	Two female participants aged 30 and 41 years. One participant with retinopathy and congenital cataract leading to total blindness by age 28.	Both participants learnt to use the system and made phone calls independently to family members, friends and staff personnel. Neither participant made calls independently at baseline. During the first intervention phase, one participant had a mean cumulative conversation time per

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Authors	Study title	Design	Domain(s) of outcomes	Location	Study objectives	Study populations	Main results/conclusions
	computer-aided telephone system				computer-aided telephone system.	One congenitally blind participant due to gestational complications.	session of ~11 minutes. The mean length of the sessions was ~21 minutes. For the second participant, mean (cumulative) conversation time per session was ~10 minutes. The mean length of the sessions was ~17 minutes.
Lorenzini & Wittich, 2021	Personalised telerehabilitation for a head-mounted low vision aid: A randomized feasibility study	Observational case-control	Patient satisfaction and recommendations	Canada	To determine the feasibility of telerehabilitation using eSight eyewear with low vision participants. Feasibility defined as achieving recruitment target, proportion of participants lost to follow up, and whether the intervention was accessible and acceptable.	57 participants; 58% male, average age 54.5 (range = 21-82) years. All were categorised as having an ocular disease, most common were optic nerve disease, AMD, RP, and retinopathy of prematurity.	Withdrawal rate was higher in the control group but did not differ significantly from the experimental group. High accessibility (93% of participants accessed the platform) and global acceptability (100% overall satisfaction) were reported among those who completed the telerehabilitation protocol. The therapist had no difficulty judging the participants' reading performances qualitatively while participants used their device to read their eSkills and VisExc guides. Most participants improved their daily activities, based on qualitative reports of the attained goals. Seventy-nine percent of individuals declined to participate, whereas 16% of participants decided not to use eSight Eyewear anymore. Positive feedback from the participants and the low vision therapist suggests the potential value of this modality for low vision services.
Lorenzini & Wittich, 2021	Head-mounted visual assistive technology-related quality of life changes after telerehabilitation	Observational case-control	Patient satisfaction and recommendations / QoL and well-being	Canada	To explore the effect of telerehabilitation (eSight eyewear) on quality-of-life and functional vision in individuals with low vision using a head-mounted display.	57 participants; 58% male, average age 54.5 (range = 21-82) years. All were categorised as having an ocular disease, most common were optic nerve disease, AMD, RP, and retinopathy of prematurity.	Assistive technology-related quality of life was improved when measured by the satisfaction scale but not the psychosocial scale within the first 3 months, independently of training type. Overall, functional vision improvement was observed within the first 2 weeks of device use and maintained during the 6-month study, independently of group type. eSight Eyewear, either with telerehabilitation or with the manufacturer

Authors	Study title	Design	Domain(s) of outcomes	Location	Study objectives	Study populations	Main results/conclusions
							self-training comparison, improved functional vision and increased users' quality of life within the initial 3 months of device training and practice.
Sabel & Gudlin, 2014	Vision restoration training for glaucoma: A randomized clinical trial	Randomised clinical trial	Vision training / QoL and well-being	Germany	To determine if behavioural activation of areas of residual vision using daily 1-hour vision restoration training for glaucoma for 3-months improves detection accuracy compared with placebo.	30 participants; 14 male; mean [SD] age 61.7 [10.1] years. 20 participants with primary open angle glaucoma; 5 with normal tension glaucoma; 4 with secondary glaucoma; 1 with angle-closure glaucoma. Mean [SD] visual acuity was 0.62 [0.34] (range 0.0-1.3 logMAR) in the right eye and 0.76 [0.40] (range 0.0-1.8 logMAR) in the left eye.	Vision restoration training for glaucoma led to significant detection accuracy gains in high-resolution perimetry ($P = .007$), which were not found with white-on-white or blue-on-yellow perimetry. Pre-post differences after vision restoration training for glaucoma were greater compared with placebo in all perimetry tests ($P = .02$ for high-resolution perimetry, $P = .04$ for white on white, and $P = .04$ for blue on yellow), and these results were independent of eye movements. Vision restoration training for glaucoma (but not placebo) also led to faster reaction time ($P = .009$). Vision-related quality of life was unaffected, but the health-related quality-of-life mental health domain increased in both groups.
Senjam <i>et al.</i> , 2021	Tele-rehabilitation for visually challenged students during COVID-19 pandemic: Lesson learned	Case report	Managing symptoms	India	To report experiences of a telerehabilitation service available primarily for students with visual disabilities amidst the COVID-19 pandemic.	492 participants; male = 388. The majority of beneficiaries were between 11 and 30 years (82.3%). Around 96% of beneficiaries were visually disabled, and 16.5% had unknown visual status (waiting or applied for certificates).	The most common ocular complaints for which beneficiaries required advice were itching ($N = 121$; 36.1%); watering eyes ($N = 54$; 16.1%); painful eyes ($N = 12$; 3.6%), redness ($N = 5$; 1.5%). Telerehabilitation can offer a safe and efficient means of providing reliable information to visually impaired individuals.

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Authors	Study title	Design	Domain(s) of outcomes	Location	Study objectives	Study populations	Main results/conclusions
Tinelli <i>et al.</i> , 2017	Development and implementation of a new telerehabilitation system for audio-visual stimulation training in hemianopia	Experimental	Vision training	Italy	To test the feasibility and efficacy of audio-visual telerehabilitation in three adult patients with chronic visual field defects.	Three participants with hemianopia. One male had cerebral stroke; one adult had drug-resistant epilepsy caused by a focal cortical dysplasia type 2a; one male had partial left homonymous hemianopia following surgery for a meningioma in the right hemisphere.	Results suggest audio-visual telerehabilitation is an effective treatment based on the stimulation of ocular movements and visual exploration functions through compensative strategies. Patients were instructed to use saccadic eye movements for the detection of visual targets and thus they showed, at the end of the treatment, an activation of the oculomotor system and a change in responsiveness toward visual stimuli, confirmed by behavioural data, mostly using the Unimodal Visual Test. The test allows patients to exercise independently in a familiar context, while under remote supervision. It may give the patient a sense of control and autonomy, which can contribute to a better therapy outcome, also reducing the need for one-to-one treatment time and home visits.

Supplementary material – Data extraction table. Data extraction table. **Key** - QoL: quality-of-life. AMD: age-related macular degeneration. DR: diabetic retinopathy. RP: retinitis pigmentosa. SD: standard deviation. logMAR: logarithm of the minimum angle of resolution. OCT: optical coherence tomography. FY: fiscal year.

Reporting checklist for systematic review (with or without a meta-analysis).

Based on the PRISMA guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the PRISMA reporting guidelines, and cite them as:

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	Reporting Item	Page Number
Title		
Title	#1 Identify the report as a systematic review	1
Abstract		

1	Abstract	#2	Report an abstract addressing each item in the	2
2				
3				
4			PRISMA 2020 for Abstracts checklist	
5				
6	Introduction			
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10	Background/rationale	#3	Describe the rationale for the review in the context	4
11				
12			of existing knowledge	
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15	Objectives	#4	Provide an explicit statement of the objective(s) or	5
16				
17			question(s) the review addresses	
18				
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20	Methods			
21				
22				
23	Eligibility criteria	#5	Specify the inclusion and exclusion criteria for the	7
24				
25			review and how studies were grouped for the	
26				
27			syntheses	
28				
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31	Information sources	#6	Specify all databases, registers, websites,	6
32				
33			organisations, reference lists, and other sources	
34				
35			searched or consulted to identify studies. Specify	
36				
37			the date when each source was last searched or	
38				
39			consulted	
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43	Search strategy	#7	Present the full search strategies for all databases,	6
44				
45			registers, and websites, including any filters and	
46				
47			limits used	
48				
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51	Selection process	#8	Specify the methods used to decide whether a	7
52				
53			study met the inclusion criteria of the review,	
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55			including how many reviewers screened each	
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57			record and each report retrieved, whether they	
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1		worked independently, and, if applicable, details of	
2		automation tools used in the process	
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5			
6	Data collection	#9 Specify the methods used to collect data from	7
7			
8	process	reports, including how many reviewers collected	
9		data from each report, whether they worked	
10		independently, any processes for obtaining or	
11		confirming data from study investigators, and, if	
12		applicable, details of automation tools used in the	
13		process	
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22	Data items	#10a List and define all outcomes for which data were	Supplementary
23		sought. Specify whether all results that were	material
24		compatible with each outcome domain in each	
25		study were sought (for example, for all measures,	
26		time points, analyses), and, if not, the methods	
27		used to decide which results to collect	
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37	Study risk of bias	#11 Specify the methods used to assess risk of bias in	8
38		the included studies, including details of the tool(s)	
39	assessment	used, how many reviewers assessed each study	
40		and whether they worked independently, and, if	
41		applicable, details of automation tools used in the	
42		process	
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51	Effect measures	#12 Specify for each outcome the effect measure(s)	N/A
52		(such as risk ratio, mean difference) used in the	
53		synthesis or presentation of results	
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1	Synthesis methods	#13a	Describe the processes used to decide which studies were eligible for each synthesis (such as tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5))	8
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13	Synthesis methods	#13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics or data conversions	N/A
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21	Synthesis methods	#13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses	Supplementary material
22				
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26	Synthesis methods	#13d	Describe any methods used to synthesise results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used	N/A
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41	Synthesis methods	#13e	Describe any methods used to explore possible causes of heterogeneity among study results (such as subgroup analysis, meta-regression)	N/A
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48	Synthesis methods	#13f	Describe any sensitivity analyses conducted to assess robustness of the synthesised results	N/A
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1	Reporting bias	#14	Describe any methods used to assess risk of bias	6
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3	assessment		due to missing results in a synthesis (arising from	
4			reporting biases)	
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9	Certainty	#15	Describe any methods used to assess certainty (or	7
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11	assessment		confidence) in the body of evidence for an outcome	
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14	Data items	#10b	List and define all other variables for which data	Supplementary
15			were sought (such as participant and intervention	material
16			characteristics, funding sources). Describe any	
17			assumptions made about any missing or unclear	
18			information	
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26	Results			
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29	Study selection	#16a	Describe the results of the search and selection	8
30			process, from the number of records identified in	
31			the search to the number of studies included in the	
32			review, ideally using a flow diagram	
33			(http://www.prisma-	
34			statement.org/PRISMAStatement/FlowDiagram)	
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41	Study selection	#16b	Cite studies that might appear to meet the inclusion	8
42			criteria, but which were excluded, and explain why	
43			they were excluded	
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51	Study characteristics	#17	Cite each included study and present its	9-15 +
52			characteristics	Supplementary
53				material
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1	Risk of bias in	#18	Present assessments of risk of bias for each	8
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3	studies		included study	
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6	Results of individual	#19	For all outcomes, present for each study (a)	N/A
7				
8	studies		summary statistics for each group (where	
9			appropriate) and (b) an effect estimate and its	
10			precision (such as confidence/credible interval),	
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16			ideally using structured tables or plots	
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18	Results of syntheses	#20a	For each synthesis, briefly summarise the	8
19				
20			characteristics and risk of bias among contributing	
21			studies	
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26	Results of syntheses	#20b	Present results of all statistical syntheses	N/A
27				
28			conducted. If meta-analysis was done, present for	
29			each the summary estimate and its precision (such	
30			as confidence/credible interval) and measures of	
31			statistical heterogeneity. If comparing groups,	
32			describe the direction of the effect	
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41	Results of syntheses	#20c	Present results of all investigations of possible	N/A
42				
43			causes of heterogeneity among study results	
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46	Results of syntheses	#20d	Present results of all sensitivity analyses	N/A
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48			conducted to assess the robustness of the	
49			synthesised results	
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1	Risk of reporting	#21	Present assessments of risk of bias due to missing	N/A
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3	biases in syntheses		results (arising from reporting biases) for each	
4				
5			synthesis assessed	
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9	Certainty of evidence	#22	Present assessments of certainty (or confidence) in	16-20
10				
11			the body of evidence for each outcome assessed	
12				
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14	Discussion			
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16				
17	Results in context	#23a	Provide a general interpretation of the results in the	16-20
18				
19			context of other evidence	
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23	Limitations of	#23b	Discuss any limitations of the evidence included in	18
24				
25	included studies		the review	
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28	Limitations of the	#23c	Discuss any limitations of the review processes	19
29				
30	review methods		used	
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34	Implications	#23d	Discuss implications of the results for practice,	16-20
35				
36			policy, and future research	
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39	Other information			
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42	Registration and	#24a	Provide registration information for the review,	7
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44	protocol		including register name and registration number, or	
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46			state that the review was not registered	
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49	Registration and	#24b	Indicate where the review protocol can be	7
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51	protocol		accessed, or state that a protocol was not prepared	
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1	Registration and	#24c	Describe and explain any amendments to	N/A
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3	protocol		information provided at registration or in the	
4				
5			protocol	
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8	Support	#25	Describe sources of financial or non-financial	20
9				
10			support for the review, and the role of the funders	
11				
12			or sponsors in the review	
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16	Competing interests	#26	Declare any competing interests of review authors	20
17				
18				
19	Availability of data,	#27	Report which of the following are publicly available	20
20				
21	code, and other		and where they can be found: template data	
22				
23	materials		collection forms; data extracted from included	
24				
25			studies; data used for all analyses; analytic code;	
26				
27			any other materials used in the review	
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 36 tool made by the [EQUATOR Network](#) in collaboration with [Penelope.ai](#)
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BMJ Open

A scoping review of remote rehabilitation (telerehabilitation) services to support people with vision impairment.

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2021-059985.R1
Article Type:	Original research
Date Submitted by the Author:	24-May-2022
Complete List of Authors:	Jones, Lee; BRAVO VICTOR; UCL, Institute of Ophthalmology Lee, Matthew; BRAVO VICTOR; Blind Veterans UK Castle, Claire L.; BRAVO VICTOR Heinze, Nikki; BRAVO VICTOR Gomes, Renata S.M.; BRAVO VICTOR; Northumbria University, Department of Nursing, Midwifery and Health
Primary Subject Heading:	Ophthalmology
Secondary Subject Heading:	Rehabilitation medicine
Keywords:	OPHTHALMOLOGY, REHABILITATION MEDICINE, Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

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3 1 **Title:** A scoping review of remote rehabilitation (telerehabilitation) services to support
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5 2 people with vision impairment.
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9 4 **Authors:**

10
11 5 Lee Jones ¹, Matthew Lee ^{1,2}, Claire L. Castle ¹, Nikki Heinze ¹, Renata S.M. Gomes
12
13 6 ^{1, 3}
14
15 7

16
17 8 **Affiliations:**

- 18
19
20 9 1. BRAVO VICTOR, Research, 12-14 Harcourt Street, W1H 4HD, London,
21
22 10 United Kingdom
23
24 11 2. Blind Veterans UK, Operations Directorate, 12-14 Harcourt Street, W1H 4HD,
25
26 12 London, United Kingdom
27
28 13 3. Northern Hub for Veterans and Military Families Research, Department of
29
30 14 Nursing, Midwifery and Health, Faculty of Health and Life Sciences,
31
32 15 Northumbria University, United Kingdom
33
34 16

35 17 **Corresponding author:** Professor Renata Gomes, Chief Scientific Officer, BRAVO
36
37 18 VICTOR. Email: renata.gomes@bravovictor.org
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41 20 **Keywords:** telerehabilitation; rehabilitation; vision impairment
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43 21 **Word count:** 6641
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22 ABSTRACT

23 **Objective:** Telerehabilitation for individuals with vision impairment aims to maintain
24 maximum physical and/or psychological functioning through remote service delivery.
25 This review aims to describe the type of telerehabilitation services available to people
26 with vision impairment and summarise evidence on health-related outcomes, well-
27 being and cost-effectiveness.

28 **Design:** Scoping review.

29 **Data sources:** CINAHL Plus, MEDLINE, PsycARTICLES, PsychINFO, Embase,
30 PubMed, HMIC and Ovid Emcare were searched, without date restrictions up to 24
31 May 2021. Charity and government websites, conference proceedings, and clinical
32 trial databases were also examined.

33 **Eligibility criteria:** Eligible studies evaluated benefits of telerehabilitation services for
34 adults with vision impairment. Studies were excluded if they were not available in
35 English, or focused on distance learning of visually impaired students.

36 **Data extraction and synthesis:** Two independent reviewers screened articles and
37 extracted data. A risk of bias analysis was performed.

38 **Outcome measures:** Measures of benefit included performance-based assessment,
39 patient-reported outcomes, and cost-effectiveness.

40 **Results:** Of 4,472 articles, 10 eligible studies were included. Outcomes addressed
41 patient satisfaction (n=4;33.3%), quality-of-life, activities of daily living, and well-being
42 (n=4;33.3%), objective visual function (n=2;16.6%), and knowledge relating to ocular
43 symptoms (n=1;8.3%). Two studies addressed multiple outcomes. Cost-effectiveness
44 was addressed in one article (8.3%). Patients were generally satisfied with their
45 experiences, which had a range of positive benefits on functional and quality-of-life
46 outcomes in areas relating to daily activities (e.g., reading, making phone calls).
47 Telerehabilitation allowed patients to undertake vision optimisation training to prevent
48 vision deterioration. Grey literature indicated there are no completed clinical trials
49 relating to low vision telerehabilitation. Charity services had implemented digital skills
50 training to help beneficiaries communicate remotely.

51 **Conclusion:** While acceptability of telerehabilitation was mostly high, limited real-
52 world data are available which raises questions around the long-term desirability of

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3 53 this Further trials are needed to evaluate telerehabilitation using a robust set of
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5 54 outcome measures.

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7 55 **PROSPERO registration number:** CRD42021254825
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For peer review only

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56 Strengths and limitations of this study

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- This review provides novel findings informing design of future trials and evaluations of telerehabilitation.
- Inclusion of grey literature reduces publication bias and increases the comprehensiveness of the review.
- Only articles written in English were included and results were seldom disaggregated by disease type or severity.

For peer review only

64 INTRODUCTION

65 Visual impairment is a broad term used to describe a reduction in visual sensitivity that
66 cannot be corrected by standard eyeglasses or medical treatment. It is estimated that
67 over 2 million people in the United Kingdom (UK) are living with a form of visual
68 impairment ⁽¹⁾. People with vision impairment may be classified as 'sight impaired' (i.e.,
69 partially sighted) or 'severely sight impaired' (i.e., legally blind) ⁽²⁾. The impact of visual
70 impairment can be complex and highly heterogenous, affecting aspects of daily
71 functioning, mobility, and quality of life ⁽³⁻⁸⁾. Among the widely prevalent ophthalmic
72 conditions such as age-related macular degeneration, glaucoma, and diabetic
73 retinopathy, loss of vision is typically progressive and irreversible; hence, support
74 relies heavily on rehabilitation to promote adaption, enabling patients to better manage
75 the challenges associated with vision loss and to live an independent and fulfilling life
76 ^(9, 10).

77 The mainstay of rehabilitation is to restore or maintain physical and/or
78 psychological functioning to the maximum degree possible in individuals living with
79 disease or injury ⁽¹¹⁾. In vision rehabilitation, eye care providers are encouraged to
80 provide rehabilitative support or refer patients to relevant services, even in cases of
81 mild or moderate sight loss ⁽¹²⁾. Rehabilitation encompasses many disciplines, and
82 interventions may include provision of visual aids, devices and software, behavioural
83 training, home environment assessments and adaptations, social and psychological
84 support, leisure and vocational activities, or a combination of these strategies ^(13, 14).
85 However, rehabilitation is characteristically structured around overcoming the practical
86 and functional challenges of sight loss, whilst psychological outcomes are seldom
87 addressed directly ⁽¹⁵⁾. The type of services which are offered often depends on the
88 nature of the visual impairment. For example, the rehabilitative needs of individuals
89 with central visual field loss may differ from those with impaired peripheral vision ⁽¹⁶⁾.
90 The traditional mode of delivery for vision rehabilitation has been in face-to-face
91 settings within outpatient clinics or home visits by low vision specialists or allied health
92 professionals; though digital developments have increased opportunity for remote
93 service delivery (i.e., telerehabilitation).

94 Telerehabilitation, also known as virtual training, refers to delivering
95 rehabilitative services using a remote or virtual approach, facilitated by
96 telecommunication technologies. Services may comprise a range of elements

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3 97 designed to assess, prevent, treat, educate, or counsel individuals living with chronic
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5 98 health conditions ⁽¹⁷⁾. Telerehabilitation services may be synchronous, whereby
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7 99 services are delivered in real-time using two-way video or audio communication, or
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9 100 asynchronous, such as remote evaluation of recorded videos or other measurements
10
11 101 such as surveys or psychophysical testing ⁽¹⁸⁾. Compared to traditional face-to-face
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13 102 rehabilitation, telerehabilitation offers potential benefits, such as reduced costs,
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15 103 increased geographical accessibility, and creating opportunities to extend limited
16
17 104 resources ⁽¹⁹⁾. Moreover, telerehabilitation has been identified as an effective means
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19 105 of delivering support to individuals with chronic conditions including multiple sclerosis,
20
21 106 osteoarthritis, and stroke ⁽²⁰⁻²²⁾.

22
23 107 Whilst there is convincing evidence to suggest telerehabilitation can be effective
24
25 108 at improving physical and psychological functioning in people living with chronic health
26
27 109 conditions ⁽²⁰⁻²²⁾, less is known about the benefits of telerehabilitation services for
28
29 110 people with a vision impairment. For example, a previous systematic review sought to
30
31 111 compare outcomes between face-to-face and virtual vision rehabilitation services, yet
32
33 112 no completed studies were found ⁽²³⁾. Additionally, new services such as remote
34
35 113 delivery of clinical care (telehealth) are likely to have emerged during the COVID-19
36
37 114 pandemic which have yet to be reviewed. This is significant given the rapid and
38
39 115 extensive scale-up of telehealth services since the beginning of the pandemic ^(24, 25).
40
41 116 This scoping review, therefore, aims to draw together evidence on telerehabilitation
42
43 117 services, and describe their impact on health and well-being outcomes in people with
44
45 118 vision impairment.

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48 120 **Objectives**

- 49 121 1. Describe the type of telerehabilitation services available to people with vision
50 122 impairment.
- 51 123 2. Provide insight on the impact of telerehabilitation in terms of health-related
52 124 outcomes, well-being and cost-effectiveness.

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128 **METHODS**

129 This review follows best practice for conducting scoping reviews as outlined by the
 130 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)
 131 extension for Scoping Reviews checklist to ensure all aspects of the process are
 132 undertaken using rigorous and transparent methods ⁽²⁶⁾. A search of the electronic
 133 databases CINAHL Plus and MEDLINE (via EBSCOhost) and PsycARTICLES,
 134 PsychINFO, Embase, PubMed, HMIC and Ovid Emcare (via Ovid) was undertaken
 135 without date restrictions or topic filters. As recommended by The Cochrane Handbook
 136 for Systematic Reviews of Interventions, medical subject headings (MeSH) were used
 137 to identify the most relevant articles ⁽²⁷⁾. MeSH terms are official words or phrases
 138 selected to represent medical concepts and are assigned to articles in order to
 139 describe what the research item is about ⁽²⁸⁾. This process provided a list of keywords
 140 relating to vision impairment and telerehabilitation. For detailed search terms, see
 141 Table 1. Reference lists of included studies and any identified systematic reviews were
 142 also reviewed for relevant articles, and citation tracking was performed using Google
 143 Scholar.

Vision impairment term		Telerehabilitation term
vision OR low vision OR vision loss OR reduced vision OR subnormal vision OR diminished vision OR vis* impair* OR sight loss OR blind* OR partially sighted	AND	telerehab* OR tele-rehab* OR remote rehab* OR virtual rehab* OR e-learning OR online learning OR online training OR telephone training OR telephone rehab* OR telephone learning OR virtual learning OR web training OR virtual training

Table 1. Search terms

145
 146 In addition, we reviewed online conference proceedings for relevant abstracts by
 147 searching the websites of the International Society of Physical and Rehabilitation
 148 Medicine; American Congress of Rehabilitation Medicine; Association for Research in
 149 Vision and Ophthalmology; American Academy of Ophthalmology; European
 150 Association for Vision and Eye Research. A search of grey literature included
 151 searching for relevant articles or reports on the websites of organisations such as the
 152 UK National Institute for Health and Clinical Excellence (NICE; www.nice.org.uk) and

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3 153 National Health Service (NHS) Evidence (www.evidence.nhs.uk). World Health
4
5 154 Organisation International Clinical Trials Registry Platform (ICTRP) and the US
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7 155 National Institute of Health trial register (ClinicalTrials.gov) were searched for ongoing
8
9 156 and completed trials relating to vision impairment and telerehabilitation. We also
10
11 157 conducted an extensive search of the UK Charity Commission website to identify
12
13 158 organisations with links to vision impairment and rehabilitation. Relevant charity
14
15 159 websites were then searched and in cases where telerehabilitation was documented,
16
17 160 any available documentation was downloaded and reviewed, and charities were
18
19 161 contacted to enquire about the current status of telerehabilitation.

19 162 **Population**

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21 163 Adult patients (aged 18 years or older) with visual impairment caused by any
22
23 164 underlying condition, medical or non-medical trauma.

25 165 **Intervention**

26
27 166 The scoping review considered how telerehabilitation services have impacted people
28
29 167 with vision impairment. Where available, evidence on cost-effectiveness will be
30
31 168 included. The review included studies where a telerehabilitation service is delivered
32
33 169 and evaluated, which could relate to improving well-being; increased social
34
35 170 participation/connectivity; maintaining activities of daily living (e.g., mobility);
36
37 171 optimisation of vision.

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39 172 Articles written in English, with no restrictions on publication period, and only where
40
41 173 the full text was available were included. Studies were required to address the
42
43 174 intervention (telerehabilitation) and population of interest (adults with visual
44
45 175 impairment). Articles were excluded if they did not relate to remote service delivery
46
47 176 (i.e., face-to-face services). Articles focusing only on an educational context (e.g., e-
48
49 177 learning) were also excluded. For example, visually impaired students using home
50
51 178 technology for distance learning.

52
53 179 Two authors (LJ and ML) independently screened studies using Covidence systematic
54
55 180 review software (Veritas Health Innovation Ltd, Melbourne, Australia; available
56
57 181 at www.covidence.org) to assess eligibility. Any disagreement in coding decisions
58
59 182 were resolved through discussion. Relevant information (e.g., publication details,
60
183 characteristics of participants, study design, outcomes measured, study results, and
184 conclusions) from eligible articles was entered into a data extraction table.

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2
3 185 Studies were assessed for quality using Kmet *et al.* 'Standard Quality Assessment
4 186 *Criteria for Evaluating Primary Research Papers from a Variety of Fields*'⁽²⁹⁾. This
5 187 quality appraisal tool was chosen because of both quantitative and qualitative studies
6 188 emerging from the literature search. The tool uses a checklist to provide guidance on
7 189 study aspects which should be considered when making a decision regarding quality
8 190 of reporting. For example, in response to the item regarding subject characteristics,
9 191 the study in question must provide at least the age and sex of participants. This review
10 192 is registered online with the International prospective register of systematic reviews
11 193 (PROSPERO; www.crd.york.ac.uk/prospero/; Reference CRD42021254825).

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15 195 **Patient and public involvement**

16 196 No patients were involved in the design of the review. We will disseminate plain
17 197 language summaries to relevant patient groups including beneficiaries of Blind
18 198 Veterans UK.

19 199

20 200 **Research ethics approval**

21 201 Ethical approval for this scoping review was not required.

202 RESULTS

203 Searches were run on 24 May 2021 and yielded 4,472 results. Of these, 658 were
204 automatically removed as duplicates. This left 3,814 studies to screen using title and
205 abstract, of which 3,719 were excluded and 95 were assessed for full-text eligibility.
206 Studies were mostly excluded at the title and abstract screening stage because they
207 did not relate to telerehabilitation or did not involve people with a vision impairment.
208 These two reasons were also the primary cause for exclusion in the full-text review
209 accounting for 17 and 38 exclusions, respectively. A further two studies were added
210 through reference list searching. Ultimately, 10 full-text studies were selected for
211 inclusion. The study selection process is shown in the PRISMA diagram in Figure 1.

<Insert Figure 1 here>

Figure 1. PRISMA diagram showing study selection process. Key: VI = vision impairment

217 Two authors (LJ and ML) independently assessed the quality of all 10 studies. The
218 lowest score was 0.64, the highest was 1.00 (i.e., all responses to relevant questions
219 in the Kmet *et al.* appraisal criteria were 'Yes'), and the median score was 0.93. Full
220 details of quality appraisal are provided in Supplementary Material 1.

221 The following overview of study findings is organised according to the main
222 outcome domains for each of the 10 articles identified in the literature search. Two
223 articles feature in more than one section as the outcomes were translatable across
224 multiple domains. Four studies (33.3%) addressed patient satisfaction^(30, 31, 32, 33), two
225 studies (16.6%) related to objective visual function ^(34, 35), four studies (33.3%)
226 measured patient-reported outcomes, activities of daily living, and well-being ^{(33, 34, 36,}
227 ³⁷⁾, one study (8.3%) addressed knowledge relating to ocular symptoms ⁽³⁸⁾, and a
228 further one study (8.3%) was an analysis of cost-effectiveness ⁽³⁹⁾. Six studies used a
229 synchronous modality whereas four studies were asynchronous in nature. For full
230 details of the included studies, refer to the data extraction table (Supplementary
231 Material 2).

232 **Patient satisfaction**

233 Four articles explored patients' satisfaction with telerehabilitation which led to
234 recommendations for key features to improve uptake of services. Three of these
235 articles reported the findings of feasibility studies ^(31, 32, 33), and one was a qualitative
236 analysis of patient experiences ⁽³⁰⁾. All of these studies included participants with a
237 visual impairment caused by a range of pathologies including age-related macular
238 degeneration, optic nerve disease, retinitis pigmentosa, and stroke-related visual field
239 deficit.

240 Dunne *et al.*'s ⁽³⁰⁾ study of stroke survivors reports the outcomes of qualitative
241 interviews and focus groups with patients and carers. The study was informed by the
242 findings of a survey of Stroke Association group members in the UK and the aims were
243 to understand experiences of a compensatory eye-movement tool and training
244 packages. The Durham Reading and Exploration Training (DREX) is a computer-
245 based telerehabilitation training system teaching adaptive eye movement strategies to
246 enable stroke survivors to cope more effectively with visual field deficits ⁽⁴⁰⁾. DREX is
247 a mobile application which incorporates tasks that combine both reading and
248 exploration (e.g., scanning an array to locate a target). In the context of rehabilitation,
249 the application is asynchronous in nature whereby healthcare professionals can
250 access and review patients' results at a later time through a clinical portal. The wider
251 study required patients with stroke-related visual field defects to complete the DREX
252 trials on a tablet in their own homes and outcomes were compared to a control
253 intervention, which consisted of attention-based tasks with no eye movement or
254 exploration exercises. Significantly greater gains were observed in visual exploration
255 (12.9%, 95% confidence interval [CI] = 8.4 to 17.3%) and reading (18.5%, 95% CI =
256 9.9 to 27.0%) following DREX than in the control intervention for both tasks,
257 respectively (exploration = 4.8%, 95% CI = 0.1 to 9.5%; reading = 1.6%, 95% CI =
258 -4.8 to 8.7%) ⁽⁴⁰⁾. Qualitative responses highlighted a range of issues in the application
259 of telerehabilitation for visually impaired stroke survivors. For example, a lack of
260 confidence with technology, perceived fear of making mistakes while online, distrust
261 of the quality of the intervention, and concerns with reduced face-to-face contact.
262 However, these issues could be addressed in initial in-person visits to alleviate
263 concerns and facilitate engagement and motivation in the rehabilitation process. One
264 challenge is that compensatory training is inherently repetitive in nature; thus,

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3 265 measures should be taken to ensure telerehabilitation tools remain accessible and
4 266 stimulating to avoid disengagement. The authors propose that one approach which
5 267 may obviate disengagement is to employ feedback and goal setting to improve
6 268 motivation and provide tangible progress updates.

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11 269 Patient satisfaction was assessed by Bittner *et al.* ⁽³¹⁾ in a pilot study to develop,
12 270 administer and evaluate a synchronous virtual low vision portal providing
13 271 telerehabilitation services. Ten patients diagnosed with either age-related macular
14 272 degeneration (n = 9) or diabetic retinopathy (n = 1) were enrolled. Participants were
15 273 required to have access to a home telephone to use the Internet-based video
16 274 conference portal. Tablet devices were provided as well as MiFi (wireless router which
17 275 acts as a mobile Wi-Fi hotspot) to enable connection to the Internet. Each participant
18 276 received one telerehabilitation session which lasted approximately one hour. The
19 277 session included administration of the MNREAD chart which consists of a series of
20 278 60-character sentences displayed over three lines and is used to assess reading
21 279 fluency and proficiency using optical magnifiers, using video and audio recordings of
22 280 the participant. Assessments of working distance and lighting were made by the
23 281 provider viewing the video of the participant reading with their magnifier, whereas
24 282 assessments of reading speed and accuracy relied on the audio component as
25 283 participants read aloud during the MNREAD and near acuity tests. The outcomes
26 284 were participants' and providers' audio and video quality ratings. Video quality was
27 285 rated as excellent to good, whereas audio ratings were more variable. All participants
28 286 were satisfied and comfortable receiving telerehabilitation and evaluation via
29 287 videoconferencing. Eight of 10 reported that their magnifier use improved after
30 288 telerehabilitation. All except one reported that they were very interested in receiving
31 289 telerehabilitation services again if their visual needs changed.

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47 290 Lorenzini and Wittich ⁽³²⁾ reported outcomes related to patient satisfaction in a
48 291 randomised feasibility study using a head-mounted display and a telehealth platform
49 292 to deliver synchronous telerehabilitation sessions at home. Participants received real-
50 293 time distance training sessions delivered by a low vision therapist. The intervention
51 294 focused on the functional aspects of using eSight eyewear, an assistive technology
52 295 designed to maximise visual input and compensate for vision loss. The intervention
53 296 group underwent a personalised training programme including eSkills functional
54 297 learning activities such as reading, writing, and distance vision training. A control group

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3 298 were randomly allocated to conventional eSight self-training using the eSkills user
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5 299 guide. Fifty-seven visually impaired participants were enrolled (experimental group, n
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7 300 = 28), the most common causes of sight loss were optic nerve disease, age-related
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9 301 macular degeneration, retinopathy of prematurity, and retinitis pigmentosa. Retention
10
11 302 rates during the study were 93% (n = 53) at 2 weeks, 68% (n = 39) at 3 months, and
12
13 303 65% (n = 37) at 6 months. A higher proportion of patients who withdrew from the study
14
15 304 were enrolled into the control group. Participants reported being comfortable with
16
17 305 receiving telerehabilitation training at home, with 16 of 23 (66%) agreeing the
18
19 306 programme was effective and efficient, and the majority (20 of 23) approving that they
20
21 307 would be interested in using telerehabilitation again in the future.

22
23 308 A parallel investigation by Lorenzini and Wittich ⁽³³⁾ used standardised
24
25 309 measures to assess quality of life and patient satisfaction following the eSight
26
27 310 telerehabilitation programme. Quality of life outcomes are reported in a later section.
28
29 311 Satisfaction was measured using the 12-item Quebec User Evaluation of Satisfaction
30
31 312 with Assistive Technology (QUEST) tool ⁽⁴¹⁾. Scores on the measure increased for
32
33 313 participants in both the experimental and control group between baseline and 3-
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35 314 months of device usage, suggesting satisfaction improved independently of the type
36
37 315 of training. There were no differences in assistive technology-related satisfaction
38
39 316 based on age or sex. Improvement in QUEST scores were not maintained at 6-
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41 317 months. The authors suggest this may be due to the device no longer meeting certain
42
43 318 needs after extended usage, or a lessening impact of social desirability, leading to
44
45 319 more realistic and honest responses from participants over time.

42 320 **Objective visual function**

44 321 Two studies focused on training related to optimisation of vision delivered through a
45
46 322 telerehabilitation service. The studies used visual exploration and ocular movement
47
48 323 tasks to activate neuroplasticity to compensate for visual loss. Both studies included
49
50 324 patients with measurable visual field loss including areas of diminished sensitivity in
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52 325 glaucoma and hemianopia in stroke patients.

53 326 Sabel and Gudlin ⁽³⁴⁾ compared outcomes of asynchronous behavioural training
54
55 327 using a 1-hour computer-based vision restoration programme for people with
56
57 328 glaucoma and a placebo group. Participants were required to have a stable
58
59 329 glaucomatous visual field defect inside 30° eccentricity in at least one eye, with well
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3 330 controlled intraocular pressure. After baseline assessments, training was performed
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5 331 6-days per week for 3-months at home on a commercially available computer with
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7 332 adaptive parameter adjustments. The experimental group performed vision training
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9 333 similar to perimetry whereby visual stimuli of varying luminance are presented in areas
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11 334 of residual vision. The placebo group performed stimulus discrimination training.
12
13 335 Vision restoration exercises led to improved vision-related performance in detection
14
15 336 accuracy as determined by high-resolution perimetry ($p=0.007$). Pre versus post
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17 337 differences after vision training for glaucoma were greater compared with placebo in
18
19 338 all perimetry tests ($p=0.02$ for high-resolution perimetry; $p=0.04$ for white-on-white
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21 339 perimetry; $p=0.04$ for blue on yellow perimetry), without affecting eye movements.
22
23 340 Moreover, the vision restoration training led to faster reaction time for the glaucoma
24
25 341 group ($p=0.009$). The authors conclude that a telerehabilitation system designed to
26
27 342 promote visual system plasticity can be used among older age adults despite
28
29 343 widespread visual deterioration, and activation of residual vision may partly reverse
30
31 344 vision loss.

32
33 345 A study on patients with hemianopia used a bespoke asynchronous audio-
34
35 346 visual telerehabilitation system ⁽³⁵⁾. The system featured a semi-circular apparatus in
36
37 347 which visual and acoustic stimuli are presented and a central camera to control head
38
39 348 and eye movements. Patients used the system at home on a customised tablet which
40
41 349 was controlled by a hospital-based therapist. Following an initial assessment in the
42
43 350 clinic, participants underwent training at home at least 5 days a week for up to 12
44
45 351 months. The aim of the training was to stimulate multisensory integration mechanisms
46
47 352 to reinforce visual and spatial compensatory functions, for example, adoption of
48
49 353 oculomotor strategies. Among the sample of three adults with hemianopia, all were
50
51 354 capable of actively using the device independently whilst under remote supervision.
52
53 355 Participants showed some improvements in visual detection abilities, which was
54
55 356 assessed using two procedures (a unimodal test using only visual stimuli presented at
56
57 357 one of 12 spatial locations lasting 100 milliseconds, and a bimodal audio-visual test
58
59 358 whereby visual stimuli was paired with sound), with the strongest effect on both testing
60
61 359 procedures observed when participants were free to use eye movements to detect
62
63 360 targets, rather than the fixed eye condition.

361 ***Quality-of-life, activities of daily living, and well-being***

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2
3 362 Four articles assessed outcomes relating to quality-of-life, activities of daily living, and
4 well-being following telerehabilitation (33, 34, 36, 37). The studies use patient-reported
5 363 outcome measures and behavioural measurements to examine the benefits of remote
6 364 interventions in people with a vision impairment. Two articles are case reports (36, 37),
7 365 and two articles describe the quality-of-life outcomes from the eSight eyewear (33), and
8 366 vision restoration training programmes (34), described in an earlier section.
9 367

10 368 Lorenzini and Wittich (33) measure changes in quality-of-life following
11 369 telerehabilitation with the eSight eyewear programme using the Psychosocial Impact
12 370 of Assistive Devices Scale (PIADS) (42), a 26-item questionnaire composed of three
13 371 subscales (competence, adaptability, and self-esteem), and the Veterans Affairs Low
14 372 Vision Visual Functioning Questionnaire (VA LV VFQ-48) (43), a 48-item instrument
15 373 used to measure subjective visual outcomes. Visually impaired participants completed
16 374 the measures at baseline, 2-weeks, 3-months, and 6-months. Results patterns were
17 375 similar across the three subscales of the PIADS showing statistically significantly
18 376 improved scores after 3 months in both the intervention and control groups ($p=0.05$),
19 377 indicating that assistive technology-related quality-of-life (i.e., perceived impact of
20 378 assistive devices on quality-of-life) improved independently of the type of training
21 379 received. Self-reported functional vision outcomes, as determined by the VA LV VFQ-
22 380 48, yielded statistically significant improvements in overall scores, as well as in
23 381 subscales (reading ($p=0.03$), visual information ($p<0.001$), mobility (<0.001)) after 2
24 382 weeks of using the device; improvements also continued after 3 months (all $p \leq$
25 383 0.05).

26 384 Sabel and Gudlin's (34) vision restoration programme used the National Eye
27 385 Institute Visual Function Questionnaire (NEI-VFQ-25) (44) and the Short-Form-36 (SF-
28 386 36) (45) to measure changes in quality of life between baseline and post-intervention
29 387 follow-up. Vision training was not associated with robust changes on these measures.
30 388 Only the mental health subscale of the SF-36 was found to have improved, which may
31 389 be caused by non-specific training effects such as attention, alertness, or expectation.
32 390 However, participants had generally scored highly on both measures at baseline,
33 391 indicating few everyday vision deficits.

34 392 A case report by Dogru-Huzmeli *et al.* (36) explored whether diplopia complaints
35 393 could be ameliorated using the Cawthorne-Cooksey exercises applied via
36 394 telerehabilitation in a multiple sclerosis patient with a visual field scotoma. Cawthorne-

1
2
3 395 Cooksey exercises use a set of eye and head movements which are based on the
4
5 396 concept of habituation and designed to build up a tolerance mechanism to support
6
7 397 equilibrium and balance ^(46, 47). Exercises were delivered synchronously through
8
9 398 WhatsApp video calls over 30 sessions. Comparison of pre- and post- eye
10
11 399 examinations suggested gaze restriction, as determined through ophthalmic
12
13 400 examination, had improved and that the patient had fewer self-reported double vision
14
15 401 complaints. Pre- and post-intervention quality-of-life was assessed using the SF-36
16
17 402 measure of general health. Analysis was based on descriptive reporting of changes in
18
19 403 scores, with no statistical analysis reported. The authors report improvement in all
20
21 404 domains of the SF-36, except for physical functioning, where there was no change.

22
23 405 A study from Lancioni and colleagues ⁽³⁷⁾ assessed whether two congenitally
24
25 406 blind women could be supported to make independent phone calls using a computer-
26
27 407 aided system. Both women attended a rehabilitation centre where the study took
28
29 408 place. The system comprised of a netbook computer which was enabled with a global
30
31 409 system for mobile communication with a headset and microphone apparatus. The
32
33 410 study adopted an ABAB design in which A represented baseline phases and B
34
35 411 represented intervention phases with the telephone system. Communication-related
36
37 412 outcomes included the total number of calls made, number of calls met with a
38
39 413 response, and length of calls. Both participants learnt to use the system and made
40
41 414 phone calls independently to a variety of contacts such as family members, friends,
42
43 415 and care staff personnel, indicating that the intervention may be useful for enabling
44
45 416 people with a vision impairment to manage phone calls on their own.

42 417 ***Knowledge relating to ocular symptoms***

44 418 One study used a telerehabilitation approach to increase knowledge of ocular
45
46 419 symptoms to support patients attending a residential school for visually impaired
47
48 420 people during the COVID-19 pandemic ⁽³⁸⁾. Senjam and colleagues ⁽³⁸⁾ used voice-
49
50 421 over internet protocols (e.g., WhatsApp calling, Zoom) to enable rehabilitation
51
52 422 practitioners at a tertiary eye centre in India to deliver therapeutic education and
53
54 423 counselling interventions and monitor ocular complaints among visually impaired
55
56 424 adults and children who were unable to attend face-to-face appointments. Over a 2-
57
58 425 month study period, 492 patients contacted the team. Health-related complaints were
59
60 426 made by 335 patients, the most common ocular complaints being itching (36.1%),
427 watering (16.1%), and painful eyes (3.6%). Counselling sessions addressed

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2
3 428 uncertainty surrounding clinical monitoring of eye health, however specific outcomes
4
5 429 of counselling were not reported.

6 7 430 **Cost-effectiveness**

8
9 431 A retrospective cost analysis from Ihrig⁽³⁹⁾ examined the economic practicality of a
10
11 432 clinical model of telerehabilitation for visually impaired military veterans.
12
13 433 Telerehabilitation was delivered by an optometrist and rehabilitation therapist to
14
15 434 veterans with conditions including age-related macular degeneration, glaucoma,
16
17 435 diabetic retinopathy, cataracts, and retinitis pigmentosa. Sessions took place remotely
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19 436 at either the participants' home or local community outpatient centre. The rehabilitation
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21 437 intervention included home adaptive skills training, which includes a home safety
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23 438 checklist, orientation and mobility training and computer training, as well as training
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25 439 with vision-related activities such as meal management, financial planning, personal
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27 440 care, and leisure time activities (Ihrig, 2014)⁽⁴⁸⁾. Total and median travel cost and time
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29 441 savings were estimated per veteran per fiscal year. Introduction of the
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31 442 telerehabilitation service in 2012 increased access to rural veterans in Western New
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33 443 York. Over a 5-year period, 419 veterans who were unable to access traditional low
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35 444 vision rehabilitation due to travel issues accessed the remote service. The proportion
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37 445 of patients accessing the telerehabilitation service represented 24% of the overall
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39 446 rehabilitation caseload. Median saving of travel miles was 122 miles per veteran
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41 447 (51,136 miles/419 veterans). Median saving of travel time was 2.09 hours per veteran
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43 448 (878 hours/419 veterans). Overall, median travel cost saving per rural individual was
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45 449 \$65.29 per veteran (\$27,357.76/419 veterans). The authors conclude that
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47 450 telerehabilitation can be a practical, time-saving, and cost-saving alternative to
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49 451 traditional face-to-face consultations.

46 452 **Grey literature**

48 453 Searches of charity websites led to the identification of 11 organisations in the UK
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50 454 where vision rehabilitation services had been shifted to remote delivery during the
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52 455 pandemic. The full list of organisations and the type of service delivery are described
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54 456 in Supplementary Material 3. The charities were contacted about telerehabilitation
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56 457 services and whether any evaluations had been undertaken. This process resulted in
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58 458 the review of seven documents, predominantly internal reports about the restructure
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60 459 of rehabilitation services during the COVID-19 pandemic. While these documents

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3 460 were mostly descriptive, there was useful information demonstrating telerehabilitation
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5 461 practice patterns in the third sector. Analysis of grey literature showed that many
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7 462 charities were reviewing their long-term rehabilitation frameworks with an indication
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9 463 that pathways will include a blended approach, offering both remote and face-to-face
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11 464 services on a personalised basis, but require further auditing and evaluation. Most of
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13 465 the organisations described implementing digital skills training to enable beneficiaries
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15 466 to become more proficient with computers and technology, such as making video calls
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17 467 and downloading smartphone applications. There were also examples of internal
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19 468 service evaluations to identify preferences in rehabilitation delivery. For example, Blind
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21 469 Veterans UK, a charity providing support and services to visually impaired UK
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23 470 veterans, reported information about the needs of their beneficiaries (including
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25 471 emotional support, befriending, assistance with shopping and using technology),
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27 472 methods in delivering remote rehabilitation (including 1:1 interventions such as
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29 473 mindfulness phone sessions and video-based group exercises), and working with
30
31 474 allied agencies throughout the COVID-19 pandemic to signpost beneficiaries to
32
33 475 support. It was notable that besides a few national sight loss charities (Blind Veterans
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35 476 UK, RNIB), the availability of telerehabilitation appeared to vary greatly, appearing
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37 477 highest within local charities in areas including Cambridgeshire, Leicestershire, and
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39 478 Nottinghamshire.

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479 The search of clinical trial databases returned two ongoing trials relevant to
480 telerehabilitation for visually impaired people, which are briefly described here. Van
481 der Aa and colleagues (Trial ID: NTR6337) will examine the feasibility of an e-mental
482 health treatment for patients with retinal exudative diseases receiving anti-VEGF
483 treatment. The cognitive behavioural therapy-based intervention is offered via the
484 Internet through the guidance of a social worker. The trial will deliver training and
485 information which aim to help patients in dealing with their eye condition and managing
486 uncertainties around treatment. The primary outcomes relate to measurements of
487 depression, anxiety, and quality of life. Another trial (NCT04926974) will evaluate the
488 efficacy of a mobile phone application to improve quality of life in older adults with low
489 vision. The application features include real-time remote personal assistance with
490 visual tasks, optical character recognition which allows text to be converted to audio
491 and read aloud, and magnifiers to aid vision. The study seeks to understand the
492 potential of these technologies to improve daily activities, community participation,

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3 493 independence, and self-sufficiency in people with low vision. Notably, there are a
4 494 range of ongoing or completed trials relating to telemonitoring of visually impaired
5 495 people, such as validation of home-based measurement tools (e.g., remote visual field
6 496 testing). Given such studies are intended to address the broader concept of home
7 497 monitoring and are not specifically within the context of rehabilitation, these trials were
8 498 not included.

14 499 ***Trends in publishing***

16 500 As shown by the results of this review, studies evaluating the impact of
17 501 telerehabilitation on people with vision impairment are beginning to emerge among the
18 502 published literature. Yet, these studies represent only a small proportion of the total
19 503 research on people with vision impairment. For example, a PubMed search for articles
20 504 with 'vision impairment' or 'blindness' in the title or abstract yielded 17,783 results
21 505 since 2010 alone; while in that same period just 10 articles (0.06%) were published
22 506 that were relevant to telerehabilitation.

29 507 **DISCUSSION**

31 508 Vision rehabilitation is a key stage in the eye care journey. Rehabilitative services can
32 509 help to mitigate the impact of vision loss by equipping patients with new skills and
33 510 training while providing social connectedness and psychological support⁽⁴⁹⁻⁵³⁾. This
34 511 review shows that the landscape of rehabilitation is evolving to include synchronous
35 512 and asynchronous approaches to remote rehabilitation for people with eye conditions.
36 513 Studies using patient-reported outcome measures suggest telerehabilitation can lead
37 514 to improved outcomes relating to self-reported daily functioning and quality-of-life^{(33,}
38 515 ^{34, 36, 37)}. In addition, there is generally a high level of acceptability from patients for this
39 516 shift in service delivery^(31, 32, 33). However, there remain certain distinct challenges
40 517 associated with telerehabilitation which may curtail the extent to which this approach
41 518 is adopted and retained more widely.

51 519 ***Measuring benefits and acceptability of interventions***

52 520 One difficulty associated with comparing results across studies is the lack of
53 521 consensus when measuring outcomes. Across all ten studies identified in this review,
54 522 27 different outcome measures were used to assess the benefits of telerehabilitation.
55 523 These included both performance-based assessments, such as psychometric testing,
56 524 and subjective or patient-reported measures of health status, visual functioning and

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3 525 quality of life. In the four studies which used patient-reported outcomes, just one
4 526 measure (SF-36) was used in more than one study. An important consideration for
5 527 clinicians, researchers and trialists could be to aim for a more unified approach when
6 528 deciding on a core set of outcome measures in future trials and evaluations of
7 529 telerehabilitation. Secondly, whilst it is encouraging that patients' views and
8 530 experiences are being considered when measuring the benefits of telerehabilitation, it
9 531 is important to consider the sensitivity of outcome measures to meaningful changes in
10 532 areas such as functionality, symptomatology, and quality-of-life etc. For example, the
11 533 non-significant changes in quality-of-life observed in the study by Sabel and Gudlin ⁽³⁴⁾
12 534 could be explained by the use of non-disease-specific measures, which may not be
13 535 sufficiently sensitive to detect small or subtle changes in visual function ⁽⁵⁴⁾. Finally,
14 536 the evidence synthesised in this review suggests that telerehabilitation is generally
15 537 regarded as acceptable by those who are willing to engage with it. Yet, acceptability
16 538 is a multifaceted concept which may not be fully explained by quantitative behaviour
17 539 metrics such as the degree of adherence or engagement with an intervention. No
18 540 studies included in this review describe a framework for acceptability, indicating further
19 541 research is needed to understand acceptability of telerehabilitation using a robust
20 542 assessment of relevant factors such as affective attitudes, opportunity costs, ethicality,
21 543 and self-efficacy; thus, future studies investigating acceptability may benefit from a
22 544 theoretical framework to guide the assessment of acceptability ⁽⁵⁵⁾.

37 38 545 ***Recommendations and challenges in practise***

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40 546 Several of the studies in this review included recommendations for
41 547 telerehabilitation which provide helpful insights. For example, a period of direct training
42 548 with home-based technology was regarded positively, suggesting such training can
43 549 provide patients with a helpful rehabilitation framework. Despite an increasing number
44 550 of visually impaired adults engaging with technology ⁽⁵⁶⁾, it is inevitable that some
45 551 individuals will have underlying concerns about their technical readiness to operate
46 552 devices at home. An assessment of individual self-efficacy regarding health
47 553 management and aptitude for telerehabilitation may, therefore, help to prioritise
48 554 individuals for whom this approach is most likely to be acceptable and successful.

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51 555 A key challenge associated with telerehabilitation is maintaining patient
52 556 motivation and engagement. Rehabilitation is, by nature, highly repetitive and often
53 557 requires engagement over long periods of time before measurable improvements in

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3 558 areas such as functional vision can be observed. Although studies in this review
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5 559 yielded good patient satisfaction ratings ⁽³³⁾ and high retention rates ⁽³²⁾, it is difficult to
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7 560 predict the sustainability of telerehabilitation outside the context of a research study.
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9 561 For example, devices risk becoming a nuisance if required long term, and whilst
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11 562 acceptable within research, patients may resist such commitments becoming the
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13 563 standard of care. Similar findings regarding the acceptability of telerehabilitation have
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15 564 been described in a recent systematic review of telerehabilitation for improving
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17 565 adaptive skills in people with multiple disabilities ⁽⁵⁷⁾, which found that patients are
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19 566 particularly satisfied with the convenience of undergoing rehabilitation from home.
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21 567 However, studies in this review described potentially intensive programmes of
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23 568 telerehabilitation, in some instances requiring several hours of engagement on
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25 569 consecutive days per week. For example, Tinelli and colleagues' ⁽³⁵⁾ participants were
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27 570 asked to use the telerehabilitation tools for 5-days per week for up to 12-months.
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29 571 Further research using real-world data on patterns of engagement with
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31 572 telerehabilitation will be a valuable addition to the literature and could help to identify
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33 573 factors associated with adherence and withdrawal, and behavioural strategies to
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35 574 encourage adoption.

33 575 ***Cost and capacity considerations***

35 576 One aspect of telerehabilitation which increases its appeal is the potential for
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37 577 substantial direct and indirect cost savings. The 2019 study by Ihrig ⁽³⁹⁾ highlighted that
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39 578 telerehabilitation was associated with considerable time and cost savings for patients
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41 579 by reducing travel requirements and fuel consumption. However, in cases where
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43 580 individual specialist equipment was required, such as the adapted telephone system
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45 581 in the study from Lancioni and colleagues ⁽³⁷⁾, costs per unit were expected to be in
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47 582 the region of \$2,000 USD. The economic value of telerehabilitation from a provider
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49 583 perspective requires more research. For example, additional costs may be incurred
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51 584 for services such as training, measurement readings, data management, and ongoing
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53 585 maintenance of many devices. Indeed, remote service delivery has been associated
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55 586 with slightly higher costs to service providers, such as speech therapy in people with
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57 587 Parkinson's disease ⁽⁵⁸⁾. Nevertheless, it could be expected that remote rehabilitation
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59 588 costs would be largely absorbed by the reduced need for time and resources required
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61 589 for non-remote services. It is noteworthy that telerehabilitation may have a wider reach
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63 590 than standard rehabilitation services, and the increased availability and convenience

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3 591 of a remote service may be more appealing to a broader profile of patients (e.g.,
4 592 working age individuals with minimal time for in-person sessions). As shown by Ihrig
5 593 ⁽³⁹⁾, remote service delivery led to an average workload increase of 24% due to a
6 594 higher number of patients accessing the service. If this finding applied to a broader
7 595 audience, there will likely be a larger rehabilitation patient caseload, with possible
8 596 capacity implications for clinical practice.

14 597 **Limitations of identified studies**

16 598 Although no studies were formally excluded on the basis of insufficient quality
17 599 (inclusion threshold set at 55% [0.55]), some common study limitations were identified.
18 600 The most frequent issues with the studies according to the Kmet et al checklist was
19 601 the presence of only a partial description of subject characteristics (2 of 10) and study
20 602 conclusions not being fully supported by the data (3 of 10). Additionally, the majority
21 603 of the studies introduce a self-selection bias when participants elect to take part in
22 604 research and are willing to engage with telerehabilitation programmes. Although
23 605 common in cross-sectional research, self-selection bias can complicate the
24 606 interpretation of study data as participants' propensity for participating in research may
25 607 correlate with the topic under investigation. For example, Lorenzini and Wittich ⁽³²⁾
26 608 report that 79% of eligible participants declined to take part in the study. As such, the
27 609 conclusions are based on a relatively small proportion of the target population.
28 610 Reasons for non-participation were seldom discussed in the published reports;
29 611 therefore, it is unclear whether factors such as level of familiarity with devices, visual
30 612 functioning, extent of sight impairment, or having assistance from a sighted friend or
31 613 family member impact on engagement with telerehabilitation. In addition, the studies
32 614 in this review report the outcomes of telerehabilitation after a relatively short period of
33 615 time (i.e., less than 1-year). As observed by Lorenzini and Wittich ⁽³²⁾, engagement is
34 616 more likely to decrease after 6 months, highlighting the need for more longitudinal
35 617 studies. A further common limitation was the relatively small sample sizes observed in
36 618 the studies. For example, four of the ten studies included in this review had a sample
37 619 size of 10 or fewer. Although this review set out to describe the type of telerehabilitation
38 620 for people with vision impairment, participants across the identified studies were
39 621 mostly low vision patients with mild or moderate visual loss; therefore, the findings
40 622 may not extend to other subgroups within the vision impairment population, such as
41 623 those with severe sight impairment or no perception of light. There are currently very

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3 624 few randomised controlled clinical trials evaluating patient outcomes in
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5 625 telerehabilitation, for example, three of the ten studies identified in this review used
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7 626 random allocation to an intervention and control group ^(32, 33, 34), and we propose this
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9 627 would be an important avenue for further research, as well as comparisons between
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11 628 traditional face-to-face and telerehabilitation services to understand the challenges
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13 629 associated with telerehabilitation in the specific context of vision impairment.

14 630 **Limitations**

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16 631 This review's methodology has a number of limitations. Only articles written in
17
18 632 English were screened and ultimately included, thus excluding potentially relevant
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20 633 studies in languages other than English. However, only three studies were excluded
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22 634 for this reason. Moreover, included studies were required to relate to some form of
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24 635 vision impairment, and several studies included heterogenous samples of varying or
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26 636 unknown degrees of sight loss from numerous conditions. A range of vision
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28 637 impairment terms were used across the studies including 'sight loss', 'blindness' and
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30 638 'low vision'. Results were rarely disaggregated by disease severity or type, thereby
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32 639 making it difficult to account for potential nuances between different patient groups
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34 640 under the broad overarching term of 'vision impairment'. A key strength of this review
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36 641 was the inclusion of grey literature. Grey literature includes a range of documents not
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38 642 controlled by commercial publishing organisations and can be a rich source of
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40 643 information which cannot be obtained from other sources ⁽⁵⁹⁾. This review highlights
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42 644 that the availability of telerehabilitation through local charity networks appeared to vary
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44 645 depending on location. While a paucity of online documentation regarding charity
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46 646 telerehabilitation services in some regions does not necessarily equate to an absence
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48 647 of such services, it does suggest a possible unevenness in their availability across
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50 648 local authorities. This may reflect broader issues pertaining to unequal access to sight
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52 649 loss support nationwide. As telerehabilitation continues to emerge as an effective and
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54 650 potentially permanent fixture in the care pathways of visually impaired people, there is
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56 651 a need to bridge the gaps in service delivery to ensure there is equitable provision
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58 652 across all areas of the UK, particularly given the potential for a wider geographical
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60 653 reach with remote services thereby increasing access to support.

656 **Conclusions**

657 In summary, the COVID-19 pandemic necessitated a redesign of traditional
658 face-to-face rehabilitation pathways to remote service delivery. A previous systematic
659 review assessing the effectiveness of low vision telerehabilitation found no studies had
660 been completed in this area ⁽²³⁾. We identified a range of remote-based rehabilitation
661 services aimed at optimising vision and encouraging adjustment to sight loss, with
662 evidence to suggest some patients are generally accepting of this model and may
663 benefit from improved functional and quality-of-life outcomes, whilst potentially offering
664 a more cost-effective approach to continuing care. The weight of the evidence
665 suggests telerehabilitation has a promising role in patient care pathways for people
666 with a vision impairment; however, issues around long-term desirability and
667 compliance remain unclear. Given the variability in patients' aptitude and motivation
668 to sustainably engage with telerehabilitation, a self-select approach which allows
669 patients to choose their preferred mode of rehabilitation delivery or individualised
670 interventions may be the most practical means of ensuring effective implementation
671 of remote services. This review has addressed increasingly relevant questions about
672 the role of telerehabilitation when applied among visually impaired people. The
673 findings to date illustrate the benefits of remote rehabilitation services, but more
674 research is needed to better understand its overall effectiveness, scalability and
675 longevity. Ultimately, we hope this review can inform key stakeholders, including
676 hospital eye services, community groups, and charities about priority areas for future
677 research and development.

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679 analysis of the work. LJ and ML performed the literature search, article screening, data
680 extraction, quality appraisal and manuscript preparation. CLC, NH, and RSMG
681 conceptualised the review and edited the manuscript. All authors approved the final
682 manuscript.

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688 **References**

- 689 1. Pezzullo L, Streatfeild J, Simkiss P, Shickle D. The economic impact of sight
690 loss and blindness in the UK adult population. *BMC Health Services Research*,
691 2018; 18: 63.
- 692 2. Royal National Institute of Blind People (RNIB). The criteria for registration.
693 Available at: [www.rnib.org.uk/eye-health/registering-your-sight-loss/criteria-](http://www.rnib.org.uk/eye-health/registering-your-sight-loss/criteria-certification)
694 [certification](http://www.rnib.org.uk/eye-health/registering-your-sight-loss/criteria-certification) [Accessed Dec 6 2021].
- 695 3. Chiang PP, Zheng Y, Wong TY, Lamoureux EL. Vision impairment and major
696 causes of vision loss impacts on vision-specific functioning independent of
697 socioeconomic factors. *Ophthalmology*, 2013; 120(2): 415-22.
- 698 4. Taylor DJ, Hobby AE, Binns AM, Crabb DP. How does age-related macular
699 degeneration affect real-world visual ability and quality of life? A systematic
700 review. *BMJ Open*, 2016; 6(12): p.e011504.
- 701 5. Fenwick EK, Ong PG, Man REK, et al. Association of Vision Impairment and
702 Major Eye Diseases With Mobility and Independence in a Chinese
703 Population. *JAMA Ophthalmology*, 2016; 134(10): 1087–1093.
- 704 6. Swenor BK, Simonsick EM, Ferrucci L, Newman AB, Rubin S, Wilson V, and
705 Health, Aging and Body Composition Study. Visual impairment and incident
706 mobility limitations: the health, aging and body composition study. *Journal of*
707 *the American Geriatrics Society*, 2015; 63(1): 46-54.
- 708 7. Jones L, Bryan SR, Crabb DP. Gradually then suddenly? Decline in vision-
709 related quality of life as glaucoma worsens. *Journal of Ophthalmology*, 2017;
710 Article ID 1621640, doi.org/10.1155/2017/1621640
- 711 8. Langelaan M, De Boer MR, Van Nispen RM, Wouters B, Moll AC, Van Rens
712 GH. Impact of visual impairment on quality of life: a comparison with quality of
713 life in the general population and with other chronic conditions. *Ophthalmic*
714 *Epidemiology*, 2007; 14(3): 119-26.
- 715 9. Burton AE, Gibson JM, Shaw RL. How do older people with sight loss manage
716 their general health? A qualitative study. *Disability and Rehabilitation*, 2016; 5,
717 38(23): 2277-85.
- 718 10. Hinds A, Sinclair A, Park J, Suttie A, Paterson H, Macdonald M. Impact of an
719 interdisciplinary low vision service on the quality of life of low vision
720 patients. *British Journal of Ophthalmology*, 2003; 87(11): 1391-6.
- 721 11. World Health Organisation. Rehabilitation. Available at: [Rehabilitation \(who.int\)](http://www.who.int/rehabilitation)
722 [Accessed May 5 2022]
- 723 12. Latham K, Macnaughton J. Low vision rehabilitation needs of visually impaired
724 people. *Optometry in Practice*, 2017; 18(2): 103-10.
- 725 13. American Academy of Ophthalmology Vision Rehabilitation Committee.
726 Preferred Practice Pattern Guidelines. Vision Rehabilitation for Adults. San
727 Francisco, CA: American Academy of Ophthalmology; 2013: Available at:
728 www.aao.org/ppp

- 1
2
3 729 14. van Nispen RM, Virgili G, Hoeben M, Langelaan M, Klevering J, Keunen JE,
4 730 van Rens GH. Low vision rehabilitation for better quality of life in visually
5 731 impaired adults. *Cochrane Database of Systematic Reviews*, 2020; (1).
6 732
7 732 15. Rees G, Ponczek E, Hassell J, Keeffe JE, Lamoureux EL. Psychological
8 733 outcomes following interventions for people with low vision: a systematic
9 734 review. *Expert Review of Ophthalmology*, 2010; 5(3): 385-403.
10 734
11 735 16. Chung ST. Enhancing visual performance for people with central vision loss.
12 736 *Optometry and vision science: official publication of the American Academy of*
13 737 *Optometry*, 2010; 87(4): 276.
14 737
15 738 17. Brennan D, Tindall L, Theodoros D, Brown J, Campbell M, Christiana D, Smith
16 739 D, Cason J, Lee A. A blueprint for telerehabilitation guidelines. *International*
17 740 *Journal of Telerehabilitation*, 2010; 2(2): 31.
18 740
19 741 18. Mechanic OJ, Persaud Y, Kimball AB. Telehealth Systems. In: StatPearls.
20 742 StatPearls Publishing, Treasure Island (FL); 2020. Available at:
21 743 www.ncbi.nlm.nih.gov/books/NBK459384/. [Accessed Dec 6 2021].
22 743
23 744 19. McCue M, Fairman A, Pramuka M. Enhancing quality of life through
24 745 telerehabilitation. *Physical Medicine and Rehabilitation Clinics*, 2010; 21(1):
25 746 195-205.
26 746
27 747 20. Cottrell MA, Galea OA, O'Leary SP, Hill AJ, Russell TG. Real-time
28 748 telerehabilitation for the treatment of musculoskeletal conditions is effective and
29 749 comparable to standard practice: a systematic review and meta-analysis.
30 749 *Clinical Rehabilitation*, 2017; 31: 625–38.
31 750
32 751 21. Yeroushalmi S, Maloni H, Costello K, Wallin MT. Telemedicine and multiple
33 752 sclerosis: A comprehensive literature review. *Journal of Telemedicine and*
34 753 *Telecare*, 2020; 26(7-8): 400-13.
35 753
36 754 22. Chen Y, Abel KT, Janecek JT, Chen Y, Zheng K, Cramer SC. Home-based
37 755 technologies for stroke rehabilitation: A systematic review. *International Journal*
38 756 *of Medical Informatics*, 2019; 123: 11-22.
39 756
40 757 23. Bittner AK, Yoshinaga PD, Wykstra SL, Li T. Telerehabilitation for people with
41 758 low vision. *Cochrane Database of Systematic Reviews*, 2020; 2.
42 758
43 759 24. Wosik J, Fudim M, Cameron B, Gellad ZF, Cho A, Phinney D, Curtis S, Roman
44 760 M, Poon EG, Ferranti J, Katz JN. Telehealth transformation: COVID-19 and the
45 761 rise of virtual care. *Journal of the American Medical Informatics Association*,
46 762 2020; 27(6): 957-62.
47 762
48 763 25. Koonin LM, Hoots B, Tsang CA, Leroy Z, Farris K, Jolly T, Antall P, McCabe B,
49 764 Zelis C, Tong I, Harris AM. Trends in the Use of Telehealth During the
50 765 Emergence of the COVID-19 Pandemic - United States, January-March
51 766 2020. *Morbidity and Mortality Weekly Report*, 2020; 69(43), 1595–9.
52 766
53 767 <https://doi.org/10.15585/mmwr.mm6943a3>
54 767
55 768 26. Tricco AC, Lillie E, Zarin W, et al. PRISMA extension for scoping reviews
56 769 (PRISMA-ScR): checklist and explanation. *Ann Intern Med* 2018; 169: 467–73.
57 769
58 770 27. Higgins JP, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA,
59 771 eds., 2019. *Cochrane handbook for systematic reviews of interventions*. John
60 772 Wiley & Sons.

- 1
2
3 773 28. Baumann N. How to use the medical subject headings (MeSH). *International*
4 774 *Journal of Clinical Practice*, 2016; 70(2): 171-4.
- 5 775 29. Kmet LM, Lee RC, Cook LS. HTA Initiative #13. Standard quality assessment
6 776 criteria for evaluating primary research papers from a variety of fields. HTA
7 777 Initiative. 2004. Available at: [https://www.ihe.ca/advanced-search/standard-](https://www.ihe.ca/advanced-search/standard-quality-assessment-criteria-for-evaluating-primary-research-papers-from-a-variety-of-fields)
8 778 [quality-assessment-criteria-for-evaluating-primary-research-papers-from-a-](https://www.ihe.ca/advanced-search/standard-quality-assessment-criteria-for-evaluating-primary-research-papers-from-a-variety-of-fields)
9 779 [variety-of-fields](https://www.ihe.ca/advanced-search/standard-quality-assessment-criteria-for-evaluating-primary-research-papers-from-a-variety-of-fields).
- 10 780 30. Dunne S, Close H, Richards N, Ellison A, Lane AR. Maximizing
11 781 Telerehabilitation for Patients With Visual Loss After Stroke: Interview and
12 782 Focus Group Study With Stroke Survivors, Carers, and Occupational
13 783 Therapists. *J Med Internet Res*, 2020; 22(10) :e19604
- 14 784 31. Bittner AK, Yoshinaga P, Bowers A, Shepherd JD, Succar T, Ross NC.
15 785 Feasibility of telerehabilitation for low vision: satisfaction ratings by providers
16 786 and patients. *Optometry and Vision Science*, 2018; 95(9): 865-72.
- 17 787 32. Lorenzini, MC, Wittich W. Personalized Telerehabilitation for a Head-mounted
18 788 Low Vision Aid: A Randomized Feasibility Study. *Optometry and Vision*
19 789 *Science*, 2021; 98(6): 570-581.
- 20 790 33. Lorenzini, MC, Wittich, W. Head-mounted Visual Assistive Technology–related
21 791 Quality of Life Changes after Telerehabilitation. *Optometry and Vision*
22 792 *Science*, 2021; 98(6): 582-591
- 23 793 34. Sabel BA, Gudlin J. Vision restoration training for glaucoma: a randomized
24 794 clinical trial. *JAMA Ophthalmology*, 2014; 132(4): 381-9.
- 25 795 35. Tinelli F, Cioni G, Purpura G. Development and implementation of a new
26 796 telerehabilitation system for audiovisual stimulation training in hemianopia.
27 797 *Frontiers in Neurology*, 2017; 8: 621.
- 28 798 36. Dogru-Huzmeli E, Duman T, Cakmak AI, Aksay U. Can diplopia complaint be
29 799 reduced by telerehabilitation in multiple sclerosis patient during the pandemic?:
30 800 A case report. *Neurological Sciences*, 2021; 1-4.
- 31 801 37. Lancioni GE, O'Reilly MF, Singh NN, Oliva D. Enabling two women with
32 802 blindness and additional disabilities to make phone calls independently via a
33 803 computer-aided telephone system. *Developmental Neurorehabilitation*, 2011;
34 804 14(5): 283-9.
- 35 805 38. Senjam SS, Manna S, Vashist P, Gupta V, Varughese S, Tandon R. Tele-
36 806 rehabilitation for visually challenged students during COVID-19 pandemic:
37 807 Lesson learned. *Indian Journal of Ophthalmology*, 2021; 69(3): 722.
- 38 808 39. Ihrig C. Travel cost savings and practicality for low-vision
39 809 telerehabilitation. *Telemedicine and e-Health*, 2019; 25(7): 649-654.
- 40 810 40. Aimola, L., Lane, A.R., Smith, D.T., Kerkhoff, G., Ford, G.A. and Schenk, T.,
41 811 2014. Efficacy and feasibility of home-based training for individuals with
42 812 homonymous visual field defects. *Neurorehabilitation and Neural Repair*, 28(3),
43 813 pp.207-218.
- 44 814 41. Demers L, Weiss-Lambrou R, Ska B. Development of the Quebec user
45 815 evaluation of satisfaction with assistive technology (QUEST). *Assistive*
46 816 *Technology*. 1996; 8(1): 3-13.

- 1
2
3 817 42. Day H. Measuring the psychosocial impact of assistive devices: the PIADS.
4 818 *Canadian Journal of Rehabilitation*. 1996; 9(2):159-68.
- 5 819 43. Stelmack JA, Szlyk JP, Stelmack TR, Demers-Turco P, Williams RT, Massof
6 820 RW. Psychometric properties of the veterans affairs low-vision visual
7 821 functioning questionnaire. *Investigative Ophthalmology & Visual Science*. 2004;
8 822 45(11): 3919-28.
- 9 823 44. Mangione CM, Lee PP, Gutierrez PR, Spritzer K, Berry S, Hays RD, National
10 824 Eye Institute Visual Function Questionnaire Field Test Investigators.
11 825 Development of the 25-list-item national eye institute visual function
12 826 questionnaire. *Archives of Ophthalmology*. 2001; 119(7): 1050-8.
- 13 827 45. Ware Jr JE. SF-36 health survey update. *Spine*. 2000; 25(24): 3130-9.
- 14 828 46. Cawthorne T. Vestibular injuries. *Proc R Soc Med*. 1946; 39(5): 270–273
- 15 829 47. Cooksey F. Rehabilitation in vestibular injuries. *Proc R Soc Med*. 1946; 39(5):
16 830 273–278.
- 17 831 48. Ihrig C. Rural healthcare pilot clinic: Low vision clinical video telehealth. *Journal*
18 832 *of the Association of Schools and Colleges of Optometry*. 2014; 40(1): 14-6.
- 19 833 49. Haymes SA, Johnston AW, Heyes AD. Preliminary investigation of the
20 834 responsiveness of the Melbourne Low Vision ADL index to low-vision
21 835 rehabilitation. *Optometry and Vision Science*, 2001; 78(6): 373-80.
- 22 836 50. Reeves BC, Harper RA, Russell WB. Enhanced low vision rehabilitation for
23 837 people with age related macular degeneration: a randomised controlled
24 838 trial. *British Journal of Ophthalmology*, 2004; 88(11): 1443-1449.
- 25 839 51. Horowitz A, Reinhardt JP, Boerner K. The effect of rehabilitation on depression
26 840 among visually disabled older adults. *Aging & Mental Health*, 2005; 9(6): 563-
27 841 70.
- 28 842 52. Stelmack JA, Szlyk JP, Stelmack TR, Demers-Turco P, Williams RT, Massof
29 843 RW. Measuring outcomes of vision rehabilitation with the veterans affairs low
30 844 vision visual functioning questionnaire. *Investigative Ophthalmology & Visual*
31 845 *Science*, 2006; 47(8): 3253-61.
- 32 846 53. Binns AM, Bunce C, Dickinson C, et al. How effective is low vision service
33 847 provision? A systematic review. *Surv Ophthalmol*, 2012; 57: 34-65.
- 34 848 54. Jones L, Garway-Heath DF, Azuara-Blanco A, Crabb DP, Bunce C, Lascaratos
35 849 G, Amalfitano F, Anand N, Bourne RR, Broadway DC, Cunliffe IA. Are patient
36 850 self-reported outcome measures sensitive enough to be used as end points in
37 851 clinical trials?: evidence from the United Kingdom Glaucoma Treatment Study.
38 852 *Ophthalmology*, 2019; 126(5): 682-9.
- 39 853 55. Sekhon M, Cartwright M, Francis JJ. Acceptability of healthcare interventions:
40 854 an overview of reviews and development of a theoretical framework. *BMC*
41 855 *Health Services Research*, 2017; 17(1):1-13.
- 42 856 56. Ali ZC, Shakir S, Aslam TM. Perceptions and use of technology in older people
43 857 with ophthalmic conditions. *F1000Res*, 2019; 8:86.
- 44 858 57. Capri T, Nucita A, Iannizzotto G, Stasolla F, Romano A, Fabio RA.
45 859 Telerehabilitation for Improving Adaptive Skills of Children and Young Adults
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3 860 with Multiple Disabilities: A Systematic Review. *Review Journal of Autism and*
4 861 *Developmental Disorders*. 2020; 8(2), 244-252.
5
6 862 58. Saiyed M, Hill AJ, Russell TG, Theodoros DG, Scuffham P. Cost analysis of
7 863 home telerehabilitation for speech treatment in people with Parkinson's
8 864 disease. *Journal of Telemedicine and Telecare*, 2020; 26: 1-6.
9
10 865 59. Adams J, Hillier-Brown FC, Moore HJ, *et al*. Searching and synthesising 'grey
11 866 literature' and 'grey information' in public health: critical reflections on three
12 867 case studies. *Syst Rev*, 2016; 5 164.
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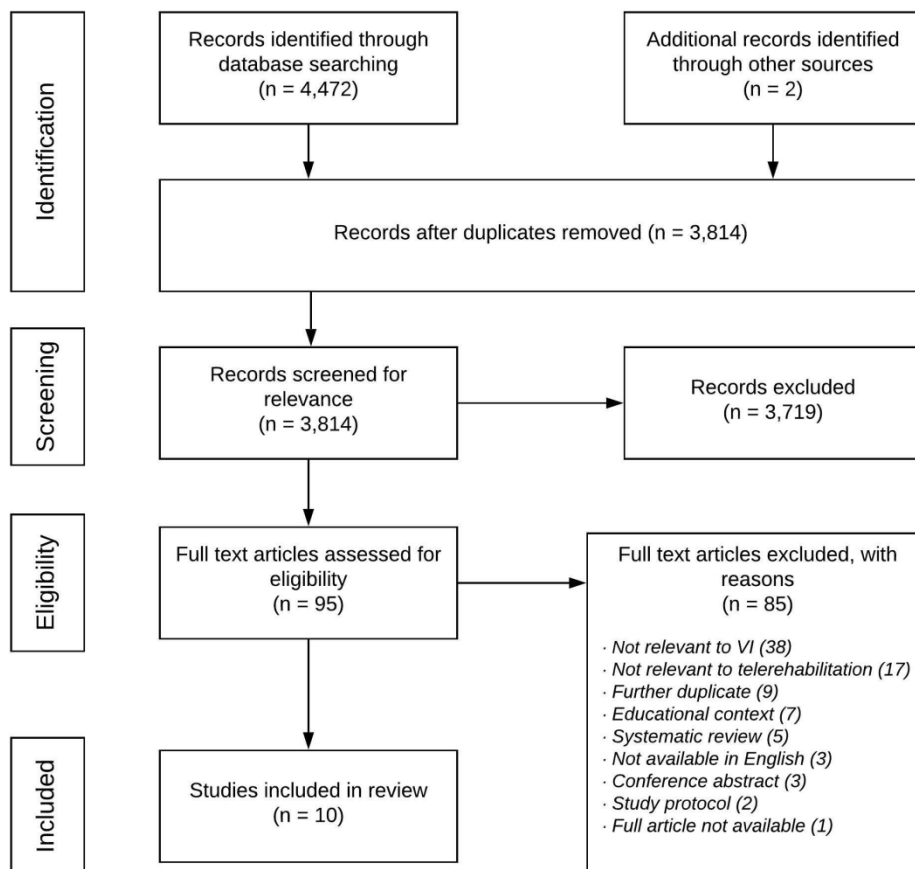


Figure 1. PRISMA diagram showing study selection process. Key: VI = vision impairment

170x159mm (300 x 300 DPI)

Supplementary material 1 – Quality appraisal

Quantitative studies (N=9)

Authors	Is the question / objective sufficiently described?	Is the study design evident and appropriate?	Is the method of subject/comparison group selection or source of information/input variables described and appropriate?	Are the Subject (and comparison group, if applicable) characteristics sufficiently described?	If interventional and random allocation was possible, was it described?	If interventional and blinding of investigators was possible, was it reported?	If interventional and blinding of subjects was possible, was it reported?	Are outcome and (if applicable) exposure measure(s) well defined and robust to measurement / misclassification bias? Are means of assessment reported?	Is the sample size appropriate?	Are the analytic methods described/justified and appropriate?	Is some estimate of variance is reported for the main results?	Controlled for confounding?	Are results reported in sufficient detail?	Are conclusions supported by the results?	Overall score
Bittner <i>et al.</i> , 2018	Yes (2)	Yes (2)	Yes (2)	Yes (2)	N/A	N/A	N/A	Yes (2)	N/A	Yes (2)	Yes (2)	N/A	Yes (2)	Yes (2)	1.00
Dogru-Huzmeli <i>et al.</i> , 2021	Yes (2)	Yes (2)	N/A	Partial (1)	N/A	N/A	N/A	Partial (1)	N/A	N/A	N/A	N/A	Partial (1)	Partial (1)	0.67
Ihrig, 2019	Yes (2)	Yes (2)	N/A	Partial (1)	N/A	N/A	N/A	Yes (2)	N/A	Yes (2)	Yes (2)	N/A	Yes (2)	Yes (2)	0.94
Lancioni <i>et al.</i> , 2011	Yes (2)	Yes (2)	N/A	Yes (2)	N/A	N/A	N/A	Partial (1)	N/A	N/A	No (0)	N/A	Yes (2)	Yes (2)	0.64
Lorenzini & Wittich, 2021	Yes (2)	Yes (2)	Yes (2)	Yes (2)	Yes (2)	Yes (2)	N/A	Yes (2)	Yes (2)	Yes (2)	Yes (2)	Yes (2)	Yes (2)	Yes (2)	1.00

1	Lorenzini & Wittich, 2021	Yes (2)	Yes (2)	Yes (2)	Yes (2)	Yes (2)	Yes (2)	N/A	Yes (2)	Yes (2)	Yes (2)	N/A	Yes (2)	Yes (2)	Yes (2)	1.00
4	Sabel & Gudlin, 2014	Yes (2)	Yes (2)	Yes (2)	Yes (2)	Yes (2)	Yes (2)	Yes (2)	Yes (2)	Partial (1)	Yes (2)	Yes (2)	Yes (2)	Yes (2)	Partial (1)	0.93
9	Senjam <i>et al.</i> , 2021	Yes (2)	Yes (2)	Yes (2)	Yes (2)	N/A	N/A	N/A	Yes (2)	N/A	N/A	N/A	N/A	Yes (2)	Partial (1)	0.93
11	Tinelli <i>et al.</i> , 2017	Yes (2)	Yes (2)	Partial (1)	Yes (2)	N/A	N/A	N/A	Yes (2)	N/A	Yes (2)	Yes (2)	N/A	Yes (2)	Yes (2)	0.94

Qualitative study (N=1)

21	Authors	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
		Question / objective sufficiently described?	Study design evident and appropriate?	Context for the study clear?	Connection to a theoretical framework / wider body of knowledge?	Sampling strategy described, relevant and justified?	Data collection methods clearly described and systematic?	Data analysis clearly described and systematic?	Use of verification procedure(s) to establish credibility?	Conclusions supported by the results?	Reflexivity of the account?				Overall score		
35	Dunne <i>et al.</i> , 2020	Yes (2)	Yes (2)	Yes (2)	Yes (2)	Partial (1)	Yes (2)	Partial (1)	Yes (2)	Yes (2)	Partial (1)				0.85		

Supplementary material 2 – Data extraction table

Authors	Study title	Design	Domain(s) of outcomes	Location	Study objectives	Study populations	Main results/conclusions
Bittner <i>et al.</i> , 2018	Feasibility of telerehabilitation for low vision: satisfaction ratings by providers and patients	Experimental	Patient satisfaction and recommendations	USA	To develop, administer, refine and evaluate components required to deliver follow-up low vision telerehabilitation services.	10 participants with self-rated vision ranging from good to poor. 9 with AMD; 1 with DR. Average age 80 (range = 63-91) years.	Providers and participants rated video quality as excellent to good. Audio quality ratings were variable, generally related to signal strength or technical issues during some sessions. All participants agreed that they were satisfied and comfortable receiving telerehabilitation. Eight of 10 reported that their magnifier use improved. All except one reported that they were very interested in receiving telerehabilitation again. Positive feedback from both participants and providers in this pilot study supports the feasibility, acceptability, and potential value of low vision telerehabilitation.
Dogru-Huzmeli <i>et al.</i> , 2021	Can diplopia complaint be reduced by telerehabilitation in multiple sclerosis patient during the pandemic? A case report	Case report	QoL and well-being	Turkey	To determine the effect of Cawthorne-Cooksey exercises applied via telerehabilitation on eye movements, vision, and quality of life in a multiple sclerosis patient with diplopia.	1 male participant with multiple sclerosis aged 39 years.	Following 4 months of telerehabilitation, the participant stated that his double vision complaints decreased, and his eyes could move more easily. When eye movements were evaluated, outward gaze restriction had improved. There was no change in visual acuity, anterior and posterior segment examinations, and OCT examination. It can be feasible to administer Cawthorne-Cooksey exercises using telerehabilitation to reduce diplopia.
Dunne <i>et al.</i> , 2020	Maximizing telerehabilitation for patients with visual loss after stroke: interview and focus group study with stroke survivors, carers, and	Qualitative	Patient satisfaction and recommendations	UK	To identify barriers and facilitators using rehabilitation tools and elements of good practice in telerehabilitation among stroke survivors.	66 focus group participants. 32 stroke survivors with partial vision loss (18 men; aged 43-83 years, mean age 62.28 years), 10 carers (7 women; 41-75 years, mean age 54.70 years), and 24	Themes identified problems associated with poststroke health care from both patients' and occupational therapists' perspectives that need to be addressed to improve uptake of telerehabilitation. Themes included identifying additional materials or assistance to boost the impact of training packages. Perceptions of technology were considered a barrier

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Authors	Study title	Design	Domain(s) of outcomes	Location	Study objectives	Study populations	Main results/conclusions
	occupational therapists					occupational therapists (19 women; 22-45 years, mean age 31.13 years)	by some but a facilitator by others. In addition, 4 key features of telerehabilitation were identified: additional materials, the importance of goal setting, repetition, and feedback.
Ihrig, 2019	Travel cost savings and practicality for low vision telerehabilitation	Cost analysis	Cost-effectiveness	USA	To evaluate patient acceptance and practicality of low vision telerehabilitation.	419 veterans, average age 83 (range = 50-101) years. 406 were male. 208 had diagnosis that resulted in non-correctable or best corrected visual acuity in both eyes up to 20/150 (defined as not legally blind); 149 had non-correctable or best corrected visual acuity in both eyes of 20/200 or worse (defined as legal blindness); 22 had non-correctable peripheral visual field loss in one or both eyes >20 degrees (defined as not legally blind); and 40 had non-correctable peripheral visual field loss in both eyes <20 degrees (defined as legal blindness).	Of the 419 veterans seen since November 2012 (FY 13), the median saving of travel miles for rural patients was 122 miles per veteran (51,136 miles/419 veterans) and the median saving of travel time was 2.09 h per veteran (878 h/419 veterans). Overall, the median saving of the travel cost per rural individual (utilizing \$0.535 per mile) was \$65.29 per veteran (\$27,357.76/419). Travel mileage and time saving resulted in an increase in access to low-vision rehabilitation (24% increase in partially sighted veterans evaluated in 5 years) by reducing the veteran's travel distance, time, and cost. Utilising low vision telerehabilitation increases early access and enables veterans who cannot travel to a specialty clinic the opportunity to prevent potential decline in functional ability over time.
Lancioni <i>et al.</i> , 2011	Enabling two women with blindness and additional disabilities to make phone calls independently via a	Case report	QoL and well-being	Italy	To assess whether two women with blindness and additional disabilities could make independent phone calls through a	Two female participants aged 30 and 41 years. One participant with retinopathy and congenital cataract leading to total blindness by age 28.	Both participants learnt to use the system and made phone calls independently to family members, friends and staff personnel. Neither participant made calls independently at baseline. During the first intervention phase, one participant had a mean cumulative conversation time per

Authors	Study title	Design	Domain(s) of outcomes	Location	Study objectives	Study populations	Main results/conclusions
	computer-aided telephone system				computer-aided telephone system.	One congenitally blind participant due to gestational complications.	session of ~11 minutes. The mean length of the sessions was ~21 minutes. For the second participant, mean (cumulative) conversation time per session was ~10 minutes. The mean length of the sessions was ~17 minutes.
Lorenzini & Wittich, 2021	Personalised telerehabilitation for a head-mounted low vision aid: A randomized feasibility study	Randomised controlled trial	Patient satisfaction and recommendations	Canada	To determine the feasibility of telerehabilitation using eSight eyewear with low vision participants. Feasibility defined as achieving recruitment target, proportion of participants lost to follow up, and whether the intervention was accessible and acceptable.	57 participants; 58% male, average age 54.5 (range = 21-82) years. All were categorised as having an ocular disease, most common were optic nerve disease, AMD, RP, and retinopathy of prematurity.	Withdrawal rate was higher in the control group but did not differ significantly from the experimental group. High accessibility (93% of participants accessed the platform) and global acceptability (100% overall satisfaction) were reported among those who completed the telerehabilitation protocol. The therapist had no difficulty judging the participants' reading performances qualitatively while participants used their device to read their eSkills and VisExc guides. Most participants improved their daily activities, based on qualitative reports of the attained goals. Seventy-nine percent of individuals declined to participate, whereas 16% of participants decided not to use eSight Eyewear anymore. Positive feedback from the participants and the low vision therapist suggests the potential value of this modality for low vision services.
Lorenzini & Wittich, 2021	Head-mounted visual assistive technology-related quality of life changes after telerehabilitation	Randomised controlled trial	Patient satisfaction and recommendations / QoL and well-being	Canada	To explore the effect of telerehabilitation (eSight eyewear) on quality-of-life and functional vision in individuals with low vision using a head-mounted display.	57 participants; 58% male, average age 54.5 (range = 21-82) years. All were categorised as having an ocular disease, most common were optic nerve disease, AMD, RP, and retinopathy of prematurity.	Assistive technology-related quality of life was improved when measured by the satisfaction scale but not the psychosocial scale within the first 3 months, independently of training type. Overall, functional vision improvement was observed within the first 2 weeks of device use and maintained during the 6-month study, independently of group type. eSight Eyewear, either with telerehabilitation or with the manufacturer

Authors	Study title	Design	Domain(s) of outcomes	Location	Study objectives	Study populations	Main results/conclusions
							self-training comparison, improved functional vision and increased users' quality of life within the initial 3 months of device training and practice.
Sabel & Gudlin, 2014	Vision restoration training for glaucoma: A randomized clinical trial	Randomised controlled trial	Vision training / QoL and well-being	Germany	To determine if behavioural activation of areas of residual vision using daily 1-hour vision restoration training for glaucoma for 3-months improves detection accuracy compared with placebo.	30 participants; 14 male; mean [SD] age 61.7 [10.1] years. 20 participants with primary open angle glaucoma; 5 with normal tension glaucoma; 4 with secondary glaucoma; 1 with angle-closure glaucoma. Mean [SD] visual acuity was 0.62 [0.34] (range 0.0-1.3 logMAR) in the right eye and 0.76 [0.40] (range 0.0-1.8 logMAR) in the left eye.	Vision restoration training for glaucoma led to significant detection accuracy gains in high-resolution perimetry ($P = .007$), which were not found with white-on-white or blue-on-yellow perimetry. Pre-post differences after vision restoration training for glaucoma were greater compared with placebo in all perimetry tests ($P = .02$ for high-resolution perimetry, $P = .04$ for white on white, and $P = .04$ for blue on yellow), and these results were independent of eye movements. Vision restoration training for glaucoma (but not placebo) also led to faster reaction time ($P = .009$). Vision-related quality of life was unaffected, but the health-related quality-of-life mental health domain increased in both groups.
Senjam <i>et al.</i> , 2021	Tele-rehabilitation for visually challenged students during COVID-19 pandemic: Lesson learned	Case report	Managing symptoms	India	To report experiences of a telerehabilitation service available primarily for students with visual disabilities amidst the COVID-19 pandemic.	492 participants; male = 388. The majority of beneficiaries were between 11 and 30 years (82.3%). Around 96% of beneficiaries were visually disabled, and 16.5% had unknown visual status (waiting or applied for certificates).	The most common ocular complaints for which beneficiaries required advice were itching ($N = 121$; 36.1%); watering eyes ($N = 54$; 16.1%); painful eyes ($N = 12$; 3.6%), redness ($N = 5$; 1.5%). Telerehabilitation can offer a safe and efficient means of providing reliable information to visually impaired individuals.

Authors	Study title	Design	Domain(s) of outcomes	Location	Study objectives	Study populations	Main results/conclusions
Tinelli <i>et al.</i> , 2017	Development and implementation of a new telerehabilitation system for audio-visual stimulation training in hemianopia	Experimental	Vision training	Italy	To test the feasibility and efficacy of audio-visual telerehabilitation in three adult patients with chronic visual field defects.	Three participants with hemianopia. One male had cerebral stroke; one adult had drug-resistant epilepsy caused by a focal cortical dysplasia type 2a; one male had partial left homonymous hemianopia following surgery for a meningioma in the right hemisphere.	Results suggest audio-visual telerehabilitation is an effective treatment based on the stimulation of ocular movements and visual exploration functions through compensative strategies. Patients were instructed to use saccadic eye movements for the detection of visual targets and thus they showed, at the end of the treatment, an activation of the oculomotor system and a change in responsiveness toward visual stimuli, confirmed by behavioural data, mostly using the Unimodal Visual Test. The test allows patients to exercise independently in a familiar context, while under remote supervision. It may give the patient a sense of control and autonomy, which can contribute to a better therapy outcome, also reducing the need for one-to-one treatment time and home visits.

Supplementary material – Data extraction table. Data extraction table. **Key** - QoL: quality-of-life. AMD: age-related macular degeneration. DR: diabetic retinopathy. RP: retinitis pigmentosa. SD: standard deviation. logMAR: logarithm of the minimum angle of resolution. OCT: optical coherence tomography. FY: fiscal year.

Supplementary Material 3 – Charities delivering remote rehabilitation

Organisation	Remote services
Beacon Centre for the Blind	Telephone-based welfare calls and befriending service. Life skills sessions to promote independent living.
Blind Veterans UK	Practical skills training including maintaining personal (e.g., managing medications) and domestic (e.g., preparing meals) activities of daily living. Remote befriending service and communication technology skills training.
Essex Sight	Telephone-based welfare calls, demonstration of equipment (e.g., kitchen aids and lighting).
Henshaws	Telephone-based welfare calls, befriending groups, physical exercise training (e.g., improving movement, strength and fitness), digital enablement services.
Galloway's	Digital skills training
My Sight Nottinghamshire	Telephone-based befriending, digital skills training, physical exercise training (e.g., chair-based and standing exercises).
Peterborough Association for the Blind	N/A
Sight for Surrey	Digital skills training, assistive technology training (e.g., screen magnification software), communication skills training, everyday living skills advice.
The Cambridgeshire Society for the Blind and Partially Sighted	Telephone-based welfare calls, peer support groups, digital skills training.
Vista	Digital skills training, assistive technology training (activating and optimising accessibility features), life skills (e.g., meal preparation), online well-being activities (e.g., singing and gardening)
The Royal National Institute for Blind People	Telephone-based counselling and befriending groups, signposting to online resources, online activities

Supplementary material – Charities delivery remote rehabilitation. **Key** - N/A: not available

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	5-6
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	6, 8
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	9
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	7-8
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	7-8
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	7
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	8
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	8 + Supplementary material
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	8 + Supplementary material
Critical appraisal of individual	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe	8-9



SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
sources of evidence§		the methods used and how this information was used in any data synthesis (if appropriate).	
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	8-9
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	10
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	10 + Supplementary material
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	10 + Supplementary material
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	Supplementary material
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	Supplementary material
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	10-19
Limitations	20	Discuss the limitations of the scoping review process.	23
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	24
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	24

JB1 = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Ann Intern Med.* 2018;169:467–473. doi: 10.7326/M18-0850.



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