How do patients with chronic dizziness experience a web-based home rehabilitation programme for customised vestibular therapy ('WeBaVeR')? A qualitative study

1 How do patients with chronic dizziness experience a web-based home
2 rehabilitation programme for customised vestibular therapy
3 ('WeBaVeR')? A qualitative study.

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15 **1. Abstract**

16 *Background*: Vestibular rehabilitation therapy (VRT) is the first choice approach for chronic dizziness.
17 However, current home treatment programmes often lack attention to the individual needs of the
18 patient and the integration of visual desensitisation therapy. We therefore developed a customised
19 web-based VRT programme containing visual desensitisation exercises.

20 *Objective*: To assess the user experience (usability, satisfaction, acceptability, and quality) of patients
21 with chronic dizziness with the customised **WE**b-**BA**sed **VE**stibular **R**ehabilitation, further called
22 'WeBaVeR'.

23 *Methods*: Patients with chronic dizziness, attending the Department of Otorhinolaryngology of the
24 Antwerp University Hospital (period September 2021 to May 2022), received a customised
25 programme, i.e. exercises supported by our web application and booklet. The programme lasted 6
26 weeks, with weekly supervision by phone. Patients' user experience was examined with the System
27 Usability Scale (SUS), Client Satisfaction Questionnaire (CSQ), Service User Technology Acceptability
28 Questionnaire (SUTAQ), and the User version of the Mobile Application Rating Scale (uMARS).

29 *Results*: Twelve patients with chronic dizziness (mean age: 45.33 ± 13.26 years) participated. The
30 overall rated level of perceived usability (mean SUS score: 78.75 ± 8.95 points), satisfaction (mean CSQ
31 score: 33.08 ± 3.37 points), acceptability (mean SUTAQ score: 105.67 ± 13.40 points) and quality (mean
32 uMARS score: 94.58 ± 10.69 points) was good. The main remarks concerned the user interface and the
33 interactive capabilities of the web application, and that WeBaVeR does not increase health awareness,
34 or accessibility to health care providers.

35 *Conclusion*: Patients with chronic dizziness consider WeBaVeR as useful, acceptable, satisfactory and
36 of good quality. To facilitate implementation in practice, further optimisation of WeBaVeR based on
37 the feedback received, is useful.

38 *Keywords*: User Experience, Chronic Dizziness, Vestibular Rehabilitation, Internet, Home Care

2. Introduction

Dizziness is a major health problem in our society. Not only is dizziness common, it is also associated with important dysfunctions at the physical (e.g., fall risk), psychological (e.g., anxiety and depression), and social levels (e.g., social isolation) [1]. Those who are anxious or avoidant about their dizziness are prone to developing persistent dizziness symptoms [2].

Vestibular rehabilitation therapy (VRT) is the therapy of choice to break the vicious cycle of chronic dizziness and its secondary effects on the individual [3-5]. Through balance and gaze stabilisation training and repeated exposure to the movements and situations that trigger dizziness (also known as "habituation"), central adaptation and compensation occurs which is necessary for the recovery process [6]. However, despite its proven effectiveness, VRT is still underutilised in primary care settings [7]. An important reason for this may be the lack of tools to perform these exercises in the home environment. Indeed, VRT needs to be performed daily (2-3 exercise sessions per day) for several weeks (guideline duration is at least 6 weeks) [8]. In many countries, an exclusively office-based approach is not feasible, given the physical (e.g., living too far from the clinic) and financial burden on patients.

Research shows that a home rehabilitation programme in the form of a web application or booklet is effective [9-12] and no more expensive than usual care for the treatment of chronic dizziness [13, 14]. However, these booklets and web applications mainly consist of generic (head) movement exercises, and do not offer materials for visual desensitisation therapy.

There is sufficient theoretical support that customised VRT is more effective than a generic exercise regimen, especially in people with delayed central compensation [15]. It also provides higher patient motivation and increased transfer of the exercises to everyday life [16, 17]. Several options for customised VRT have been described in the literature (e.g., for gaze stabilisation [18], balance [19] and habituation training [20, 21]). In addition, studies show the importance of integrating visual desensitisation in VRT [22]. This may be explained by the fact that over-reliance on visual information is a common malcompensation that contributes to persistent dizziness symptoms, and thus should be treated [23-25].

Despite recent new studies on VRT [12, 26-28], the feasibility and effectiveness of a home VRT tool, which offers tailored exercises and accompanying assisting materials for gaze stabilisation, balance, movement habituation and visual desensitization therapy, have not yet been adequately investigated [29]. We therefore developed our own customised **We**b-**Ba**sed **Ve**stibular **R**ehabilitation therapy, further referred to as 'WeBaVeR'

The purpose of this study was to evaluate the user experience (usability, satisfaction, acceptability, and quality [30]) of patients with chronic dizziness with the customised WeBaVeR.

3. Methods

3.1. Design and setting

This study was designed according to the STROBE guidelines for cohort studies [31]. The study protocol was approved by the Medical Ethics Committees of the Antwerp University Hospital (reference number 18/586).

79 Patients visiting the Department of Otorhinolaryngology of the Antwerp University Hospital (Belgium)
80 during the period September 2021 to May 2022 were recruited. Study investigations took place at the
81 Multidisciplinary Motor Centre Antwerp (M²OCEAN), which is the movement analysis lab of the
82 University of Antwerp/MOVANT. Participation was voluntary, and could be discontinued at any time
83 at the patient's request. Participating patients signed the informed consent form.

3.2. Participants

85 To participate, the patient had to (1) suffer from chronic non-rotatory dizziness (i.e., have vestibular
86 symptoms at least 15 days per month for at least 3 months); (2) be at least 18 years old; and (3) be
87 Dutch-speaking. In the presence of any of the following criteria, the patient was refused: (1) acute
88 vestibular dysfunction; (2) dizziness due to hormonal disorders, untreated metabolic or cardiac
89 disorders, vasovagal syncope, hyperventilation, acute psychological problems, or substance abuse; (3)
90 balance problems other than those caused by dizziness (such as orthopaedic and neurological
91 disorders); (4) significant visual disturbances that cannot be corrected by, for example, wearing
92 glasses; and (5) not having an email account or access to the Internet.

93 Patients' eligibility was checked by an Ear-Nose-Throat (ENT) doctor through anamnesis (according to
94 the SO STONED method [32]), and through micro-otoscopic, vestibular (includes video head impulse,
95 sinusoidal harmonic acceleration, and binaural bithermal caloric testing) and audiometric screening. If
96 eligible, patients were referred to the study investigator (licensed physiotherapist at master's degree).

3.3. Study procedure

98   The study investigator performed a baseline assessment for each patient (i.e., Dizziness Handicap
99   Inventory, DHI; Visual vertigo Analogue Scale, VVAS; Static Balance Tests; and Functional Gait
100 Assessment, FGA; as described in [33]). This served as the basis for an individualised VRT programme.
101 WeBaVeR (**TABLE 1**) was supported by a booklet with customised vestibular exercises (i.e. gaze
102 stabilisation, balance, movement habituation, visual desensitisation and neck exercises; depending on
103 the patient's needs), and the web application for which the patients received a secure login (**FIGURE
104 1, a-c**). In addition, all patients received an information brochure and a diary.
105 For example, individualised exercises meant that if the baseline assessment showed high levels of
106 visually induced dizziness (VVAS ≥ 30%), visual desensitisation exercises were included; if it was found
107 that turning in bed, looking up or bending (on the DHI questionnaire) or turning in standing (on the
108 FGA) provoked vestibular symptoms, habituation exercises were included for training these specific
109 movements. An example of how exercises were selected and progressively increased in difficulty for
110 patients with high versus low VVAS scores can be found in **APPENDIX A**.

111 The patient was followed up by the study investigator. Each component of WeBaVeR was verbally
112 explained to the patient at the start. The patient was informed to perform the exercises (4 à 6 in total)
113 independently at home for 6 weeks twice a day, 7 days per week (with each session lasting 10 to 15
114 minutes). The required exercise intensity (e.g., frequency, speed and duration) was determined by mild
115 to moderate provocation of the dizziness, provided the patient could tolerate it. In order to maintain
116 sufficient exercise intensity, the content and progression of the exercises were adjusted weekly via
117 telephone supervision (+/- 30 minutes), depending on the change in the patient's clinical condition.
118 This meant that exercises that no longer caused dizziness or caused little dizziness were made more
119 difficult (e.g., by increasing speed, number of repetitions, or addition of double tasks and visual

120　disturbance), or were replaced by a different exercise. Patients could also contact the study
121　investigator at any time within working hours (8:30 am to 7:00 pm). After the 6 weeks, patients were
122　allowed to continue to use WeBaVeR without further follow-up from the study investigator.

123

124　**Table 1.** *Content of WeBaVeR* [a]

Components	Description
Information brochure	The brochure provides background information on the development of vestibular symptoms and the importance of vestibular exercises. For example, it explains that exercises that elicit vestibular symptoms are necessary to obtain vestibular compensation; that vestibular symptoms may initially worsen but will diminish as the exercise program is continued; and that it is important to remain physically active. In case of any adverse events (e.g., head/ear pain, double vision, tinnitus), although rare, contacting the Ear-Nose-Throat doctor and/or general practitioner is recommended.
Diary	The diary was designed to record daily what exercises were performed, at what intensity, and to what extent vestibular symptoms occurred with each exercise and after completion of the exercise session. In addition, physical activities performed (e.g., cycling, swimming, walking) and other remarks could be noted. The diary was sent to the study investigator 1 day before the telephone consult, in order to be discussed with the patient.
Booklet	The booklet contains 4 to 6 patient-tailored exercises to be chosen (by the study investigator) from the categories of *Gaze Stabilisation*, *Balance*, *Movement Habituation*, Visual Desensitisation and/or *Neck*, depending on the patient's needs. Each exercise and how to perform it is described in detail to the patient with an accompanying figure. Various progression options (e.g., speed, duration, dual task) are also listed, which are chosen in consultation with the study investigator. 1) Category *'Gaze Stabilisation'* Aiming to improve the ability to focus the gaze during head movements. There is a choice of oculomotor (e.g., saccades, smooth pursuit), vestibulo-ocular reflex (e.g., VOR x1, VOR x2) and cervico-ocular reflex exercises. 2) Category *'Balance'* Aiming to improve static and dynamic balance. There is a choice of various exercises in which balance is challenged by, for example, changing the base of support, swinging the arms, or throwing an object. 3) Category *'Movement Habituation'* Aiming to improve tolerance to head and/or body movements. There is a choice of various movements, for example, shaking the head, bending over, turning in a lying or standing position. 4) Category *'Visual Desensitisation'* Aiming to reduce hypersensitivity to visual stimuli. There is a choice of different static and dynamic images that can be either realistic or abstract (more information, see component '*Web Application*'). 5) Category *'Neck'* Aiming to reduce secondary neck complaints. Various exercises for neck mobilisation and motor control can be selected.

Web application (**FIGURE 1, a-c**)	The web application contains instructional videos and exercise materials to support the booklet. An instructional video (with spoken instructions) is available for each exercise to visually clarify how the exercises should be performed. In addition, exercise materials are available for performing the gaze stabilisation and visual desensitisation exercises. (a) For gaze stabilisation, one or more targets can be placed on the screen and different background images can be selected. Various adjustment parameters are available (e.g., colour, size, speed, and addition of text or metronome). (b) For visual desensitisation, static and dynamic images can be selected, which can be realistic (e.g., patterned floor, fruit basket, supermarket) or abstract (e.g., tunnel, dots, stripes).
[a] VOR = vestibulo-ocular reflex; WeBaVeR = customised **We**b-**Ba**sed **Ve**stibular **R**ehabilitation therapy	

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128 **Figure 1.** *The designed web application as a support for the vestibular booklet.*

129 *a) Example of an instructional video from the category 'Balance'* [a]
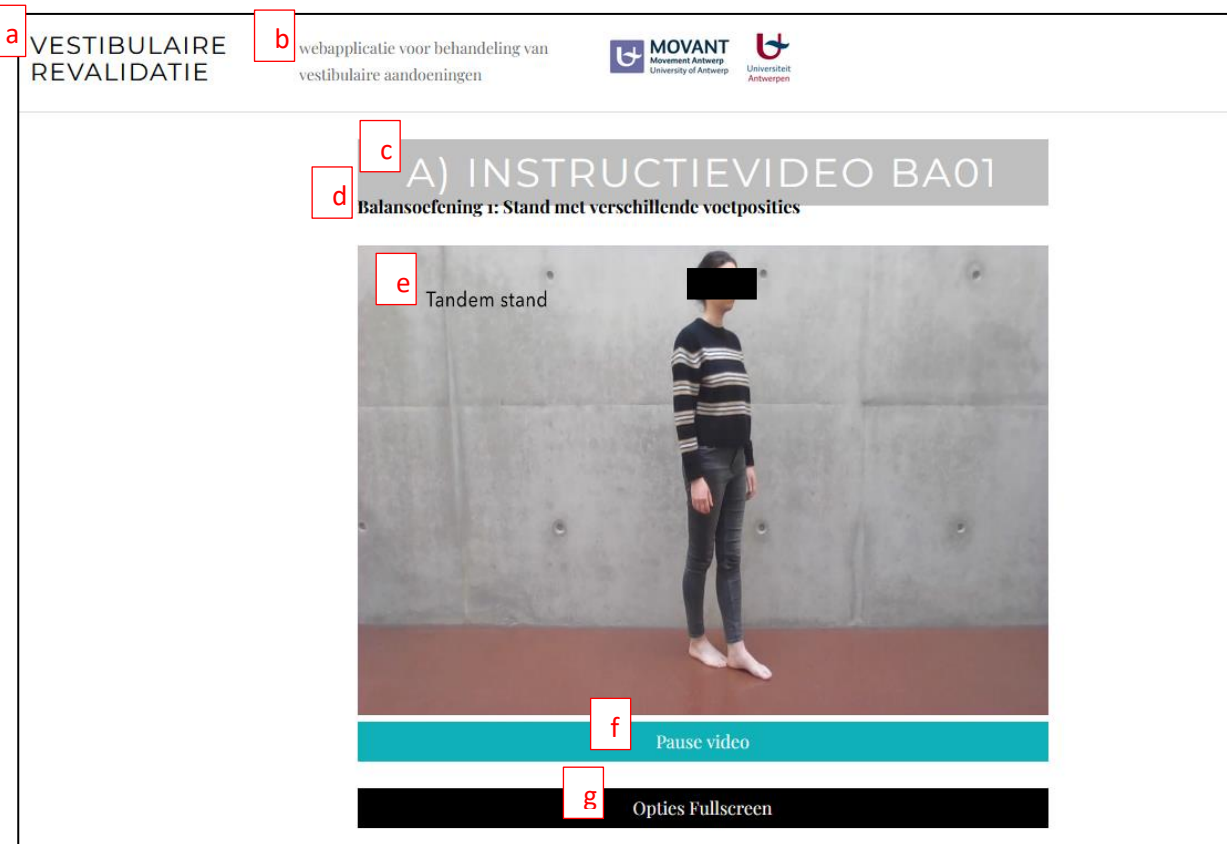
130–143

144 [a] Translation from Dutch to English: (a) Vestibular rehabilitation; (b) Web application for treatment of
145 vestibular disorders; (c) Instructional video BA01; (d) Balance exercise 1: Standing with different foot
146 positions; (e) Tandem stance; (f) pause the video; (g) full screen option

147 *b) Example of exercise material from the category 'Gaze Stabilisation'* [a]
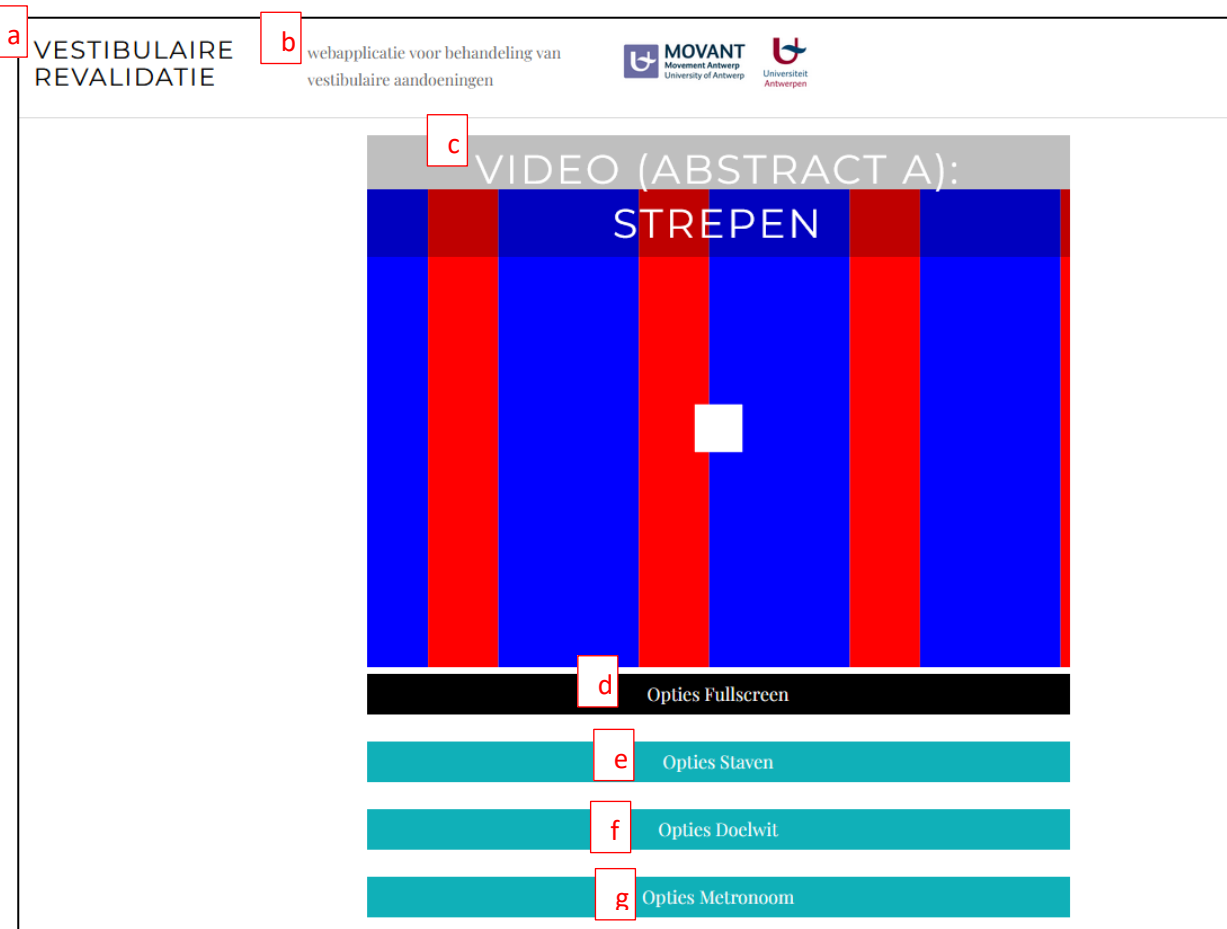
167   *c) Example of exercise material from the category 'Visual desensitisation'* [a]

184   [a] Translation from Dutch to English: (a) Vestibular rehabilitation; (b) Web application for treatment of
185   vestibular disorders; (c) Static (realistic): supermarket aisle; (d) Full screen options; (e) Options for
186   image; (f) Options for target; (g) Options for metronome

187 After 6 weeks of therapy, patients were asked to indicate their user experience with WeBaVeR through
188 four questionnaires (See '3.4. Outcome variables'). The completed questionnaires were delivered
189 electronically to the study investigator, who checked whether all questions had been answered and, if
190 not, contacted the patient to complete them further.

191 3.4. Outcome variables

192 3.4.1. Descriptive variables

193 Demographic data on *age (years), gender, dizziness duration (years)*, and *ENT diagnosis* were taken
194 from the patient's electronic medical record.

195 Baseline assessment data were collected on the *DHI, VVAS, Static balance tests,* and *FGA*, as described
196 in [33].

197 3.4.2. User experience variables

198 The *System Usability Scale (SUS)* assesses the perceived usability of WeBaVeR by asking about the
199 complexity of the content and the need for prior training or support. It contains a total of 10 questions,
200 each to be scored using a 5-point Likert scale (ranging from strongly disagree (1) to strongly agree (5)).
201 For questions 1,3,5,7 and 9, the score contribution is the "scale position minus 1", and for questions
202 2,4,6,8 and 10, the score contribution is "5 minus the scale position". The sum of the scores on all
203 questions, multiplied by 2.5, constitutes the total SUS score [34]. The total score is between 0 and 100
204 where the higher the score the higher the perceived usefulness of WeBaVeR. Of the various methods
205 available to interpret the total SUS score, the grading and adjective methods are used (see **FIGURE 2**)
206 [35].

207 **Figure 2.** *The grading and adjective methods to interpret the SUS scores.* [a, b, c]

208
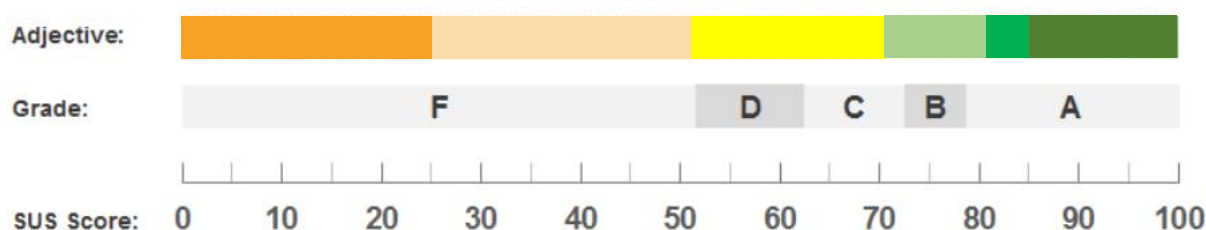
209 [a] Legend: ■ Best imaginable ■ Excellent ■ Good ■ Fair ■ Poor ■ Worst imaginable
210   A = superior performance; B = good performance; C = average performance; D = reduced
211   performance; F = failing performance
212 [b] Figure adapted from https://measuringu.com/interpret-sus-score [35]
213 [c] SUS = System Usability Scale

214

215 The *Client Satisfaction Questionnaire (CSQ)* measures satisfaction with WeBaVeR by evaluating, for
216 example, the service received and the therapy duration. It contains a total of 10 questions, each scored

217 on a 4-point Likert scale (ranging from strongly not satisfied (1) to strongly satisfied (4)). The total score
218 ranges between 10 and 40, with a higher score indicating higher satisfaction [36].

219 The *Service User Technology Acceptability Questionnaire (SUTAQ)* assesses the acceptability of
220 WeBaVeR using 22 questions that can be broken down in 6 sub-items: 'enhanced care' (5 items),
221 'increased accessibility' (4 items), 'privacy and discomfort' (4 items), 'caregiver concerns' (3 items),
222 'WeBaVeR as substitution' (3 items) and 'satisfaction' (3 items). Each question should be scored using
223 a 6-point Likert scale ranging from strongly disagree (1) to strongly agree (6). However, the sub-items
224 'privacy and discomfort' and 'caregiver concerns' contain negative statements, meaning that the lower
225 the score here, the higher the acceptability. The total score on the SUTAQ was calculated by first
226 reversing the scores for the negative statements, and then summing up the scores on the 22 questions.
227 The total score ranged between 22 and 132, with the higher the score the higher the acceptability.[37].

228 The *User version of the Mobile Application Rating Scale (uMARS)* focuses solely on evaluating the
229 quality of WeBaVeR's web application. 'Objective quality' is estimated with 16 questions that can be
230 divided into 4 domains: 'Engagement' (5 items), 'Functionality' (4 items), 'Aesthetics' (3 items), and
231 'Information' (4 items). In addition, there are 4 questions on 'subjective quality', which can be used to
232 estimate whether the patient would use this web application in the future. Finally, there are 6
233 questions that gauge the possible positive effect of the web application on health habits, i.e. 'Perceived
234 impact'. Each of the 26 questions was scored on a 5-point Likert scale. An average score for objective
235 quality, subjective quality and perceived impact was calculated separately, as well as the total score
236 on the uMARS. In each case, the higher the score the higher the quality, and/or positive effect of the
237 web application on health habits was estimated [38].

3.5. Established double translation method

239 Only an English version of the SUS, SUTAQ, and uMARS was available in the literature. Therefore, these
240 questionnaires were translated into Dutch using an established double translation method [39]. The
241 forward translation was done by an informed (i.e. who was aware of the concept measured by the
242 questionnaires) and an uninformed bilingual translator whose mother tongue was Dutch. Translation
243 differences were limited and discussed between the translators until a consensus was reached. Then,
244 these Dutch versions of the questionnaires were translated back into English by an informed and an
245 uninformed bilingual translator whose native language was English (British). The differences in
246 translation were limited here as well, and there were no changes in meaning between the agreed
247 English versions and the original questionnaires. Consequently, these Dutch-language versions of the
248 questionnaires were used in this study.

3.6. Data analysis

250 All data were collected pseudonymised in a Microsoft Excel 2016 spreadsheet. Statistical analyses were
251 then performed via SPSS software version 27.0 [40]. All documents remained localised on the secure
252 server of the University of Antwerp.

253 The sub/total scores on the user experience questionnaires were calculated according to the guidelines
254 from the literature (SUS [35], CSQ [36], SUTAQ [37], en uMARS [38]).

255 The descriptive data and results on the user experience questionnaires were analysed using means
256 and standard deviations (SD) for all quantitative variables, and frequencies and percentages for all
257 categorical variables.

258

259 **4. Results**

260 4.1. Study participants

261 A total of 12 patients with chronic dizziness aged 23 to 65 years, with a mean age of 45.33 ± 13.26
262 years, participated in this study. All patients were diagnosed with PPPD, with the precipitating events
263 being varied: vestibular migraine (N=4), bilateral vestibulopathy (N=2), vestibular neuritis (N=1),
264 benign paroxysmal positional dizziness (N=1), vestibular schwannoma (N=1), cardiovascular event
265 (N=1), SARS-CoV-2 infection (N=1), and concussion (N=1). Their demographic and baseline
266 characteristics are presented in **TABLE 2**.

267

268 **TABLE 2.** *Demographic and baseline assessment data of the participants (N=12)* [a]

Variables	Mean ± SD or number (%)
Age (years)	45.33 ± 13.26
Female	4 (33.3)
Dizziness duration (months)	31.00 ± 43.45
Dizziness Handicap Inventory (0-100 points)	48.50 ± 11.79
Visual Vertigo Analogue scale (%)	52.24 ± 23.24
Static balance tests (0-120s)	83.32 ± 27.11
Functional Gait Assessment (0-30 points)	26.67 ± 2.15

269 [a] SD = standard deviation (+/- 1 SD)

270 4.2. Patients' experience with WeBaVeR

271 For a detailed overview of the scores given per questionnaire by the patients, please consult the
272 **APPENDIX B**.

273 4.2.1. Evaluation of the usability

274 **TABLE 3** presents the mean scores (± SD) for each question.

275 The mean total score on the SUS was 78.75 ± 8.95 points, which means that, based on the grading and
276 adjective scoring methods, the perceived usability of WeBaVeR was generally considered as good [35].
277 All patients felt confident in using WeBaVeR, and almost all felt that WeBaVeR was easy to use, without
278 the need of a technical person. The different components of WeBaVeR were considered to be well
279 integrated. Most discordance was present on whether much learning was required to use WeBaVeR.

280

281 ***Table 3.*** *Mean scores (± SD) for each question on the SUS* [a, b, c]

Sub-items	Mean ± SD
SUS 1	3.83 ± 0.72
SUS 2	1.92 ± 0.67
SUS 3	4.08 ± 0.90
SUS 4	1.33 ± 0.65
SUS 5	4.08 ± 0.51
SUS 6	1.58 ± 0.79
SUS 7	3.92 ± 0.90
SUS 8	1.92 ± 0.51
SUS 9	4.58 ± 0.51
SUS 10	2.25 ± 1.36
Total score (0-100 points)	78.75 ± 8.95

282

283 [a] SD = standard deviation (+/- 1 SD); SUS = System Usability Scale
284 [b] Questions: **SUS_1**: I think I would like to use WeBaVeR frequently; **SUS_2**: I found WeBaVeR
285 unnecessarily complex; **SUS_3**: I thought WeBaVeR was easy to use; **SUS_4**: I think that I would need
286 the support of a technical person to be able to use WeBaVeR; **SUS_5**: I found the various parts in
287 WeBaVeR were well integrated; **SUS_6**: I thought there was too much inconsistency in WeBaVeR;
288 **SUS_7**: I would imagine that most people would learn to use WeBaVeR very quickly; **SUS_8**: I found
289 WeBaVeR very awkward to use; **SUS_9**: I felt very confident using WeBaVeR; **SUS_10**: I needed to learn
290 a lot of things before I could get going with WeBaVeR.
291 [c] More information on the SUS scoring can be found in *3.4.2. User experience variables*.

292

293 ## 4.2.2. Evaluation of the satisfaction

294 **TABLE 4** presents the mean scores (± SD) for each question.

295 With a mean total CSQ score of 33.08 ± 3.37 points, satisfaction was high (the minimum CSQ score is
296 10 and the maximum score is 40; a higher score means a higher degree of satisfaction). A small minority
297 felt that the exercise period was too short and that the termination of the exercise program was
298 therefore not a joint decision between the patient and study investigator.

299

300

Table 4. *Mean scores (± SD) for each question on the CSQ* [a, b, c]

Sub-items	Mean ± SD
CSQ 1	3.25 ± 0.62
CSQ 2	3.33 ± 0.65
CSQ 3	3.08 ± 0.67
CSQ 4	3.50 ± 0.67
CSQ 5	3.25 ± 1.06
CSQ 6	3.33 ± 0.49
CSQ 7	3.25 ± 0.62
CSQ 8	3.42 ± 0.67
CSQ 9	3.17 ± 0.72
CSQ 10	3.50 ± 0.67
Total score (10-40 points)	33.08 ± 3.37

[a] SD = standard deviation (+/- 1 SD); CSQ = Client Satisfaction Questionnaire

[b] Questions: **CSQ_1**: How do you find the quality of WeBaVeR?; **CSQ_2**: Was this the kind of help you were hoping to get?; **CSQ_3**: To what extent has WeBaVeR met your needs?; **CSQ_4**: If an acquaintance needed the same help, would you recommend our WeBaVeR?; **CSQ_5**: Overall, did you find the length of the exercise period sufficient?; **CSQ_6**: Did you feel you were able to practice adequately?; **CSQ_7**: Did WeBaVeR help you cope better with your problems?; **CSQ_8**: Overall, how satisfied are you with WeBaVeR you received?; **CSQ_9**: To what extent was the conclusion of treatment a joint decision between you and the caregiver?; **CSQ_10**: Suppose you ever seek help again, would you come back to us?

[c] More information on the CSQ scoring can be found in *3.4.2. User experience variables*.

4.2.3. Evaluation of the acceptability

TABLE 5 presents the mean scores (± SD) for each sub-item.

WeBaVeR was generally considered highly acceptable. The mean total score on the SUTAQ was 105.67 ± 13.40 points (the minimum SUTAQ score is 22 and the maximum score is 132; a higher score means a higher degree of acceptance).

Sub-item *Enhanced Care*: The care was generally considered improved with WeBaVeR. Two items were scored slightly lower, namely whether this tool could be used to better monitor the patient and their condition, and whether it could make the patient less anxious about their health/social care.

Sub-item *Increased Accessibility*: There was some ambiguity as to whether WeBaVeR increases accessibility, for example to health and social care professionals, and saves time compared to a physical consultation. Nevertheless, patients considered WeBaVeR to be beneficial to their health.

Sub-item *Privacy and Discomfort*: There was unanimity that there was no invasion of privacy. However, it was reported that WeBaVeR could possibly affect daily routine and lead to uncomfortable feelings (e.g., emotionally or physically).

Sub-item *Care personnel Concerns*: There was a high level of confidence in the expertise of the caregivers involved in the patient's treatment with WeBaVeR. However, three patients indicated that WeBaVeR may interfere with the continuity of their received care in general.

Sub-item *Satisfaction*: There was a high degree of satisfaction with WeBaVeR.

Sub-item *WeBaVeR as Substitution*: There was uncertainty about whether WeBaVeR can replace regular face to face consultations, or other regular health or social care. There was some agreement that WeBaVeR causes patients to worry less about their health status.

Table 5. Mean scores (± SD) on the six sub-items of the SUTAQ [a, b]

Sub-items (score range)	Mean ± SD
1) Enhanced Care (5-30 points)	24.58 ± 3.23
2) Increased accessibility (4-24 points)	17.00 ± 5.44
3) Privacy and discomfort (4-24 points)	7.33 ± 3.00
4) Care personnel concerns (3-18 points)	4.67 ± 1.78
5) Satisfaction (3-18 points)	16.50 ± 2.02
6) WeBaVeR as substitution (3-18 points)	11.08 ± 3.34
Total score (22-132 points)	105.67 ± 13.40

[a] SD = standard deviation (+/- 1 SD); SUTAQ = Service User Technology Acceptability Questionnaire; WeBaVeR = customised **We**b-**Ba**sed **Ve**stibular **R**ehabilitation

[b] More information on the SUTAQ scoring can be found in *3.4.2. User experience variables*.

4.2.4. Evaluation of the quality

TABLE 6 presents the mean scores (± SD) for the objective quality (including the 4 domains), the subjective quality, and the positive effect of WeBaVeR on health habits.

With a mean total score on the uMARS of 94.58 ± 10.69 points, the web application was generally considered to be of sufficient quality. Strengths of the web application were its clear and reliable content, with good visual support, which was adapted to its target group. The application would also be recommended by the patients to others with the same pathological condition.

The main drawback of the web application was that there were few interactive features and the application was not very attractive visually.

Contradictions in the responses were present on whether or not the web application has a positive effect on health awareness and habits. There was also discussion about the degree of possible customisation (e.g., notifications), and whether they would continue to use the web application and pay for it.

Table 6. Mean scores (± SD) on the three sub-items of the uMARS [a, b]

Sub-items (score range)	Mean ± SD
1) Objective quality (16-80 points)	59.83 ± 5.32
A. Engagement (5-25 points)	17.33 ± 2.50
B. Functionality (4-20 points)	15.58 ± 1.88
C. Aesthetics (3-15 points)	10.00 ± 2.00
D. Information (4-20 points)	16.92 ± 1.44
2) Subjective quality (4-20 points)	14.58 ± 2.64
3) Perceived impact (6-30 points)	20.17 ± 5.20

Total score (26-130 points)	94.58 ± 10.69

358

5. Discussion

The aim of this study was to evaluate the user experience of patients with chronic dizziness with WeBaVeR, a web-based home VRT programme. The results of this study show that WeBaVeR is a useful, acceptable, satisfactory and quality telemedicine method.

The peculiarity of WeBaVeR compared to other VRT methods is twofold. On the one hand, WeBaVeR allows exercises to be selected and tailored to the individual patient. Indeed, research shows that it is more effective to perform exercises that provoke the patient's dizziness [5, 41] and that are focused on his/her daily life [42]. The effectiveness and possibilities for exercise progression have been described in the literature [18, 19, 41], and became possible in WeBaVeR thanks in part to the different adjustable parameters on the web application. A second special feature of WeBaVeR is the visual desensitisation therapy, the relevance of which in chronic dizziness has already been sufficiently confirmed in the literature [25, 43, 44]. Through the web application, there is a wide choice of both realistic and abstract images/videos. The many adjustable parameters also result here in a patient-specific approach, without getting too complex for both the patient and the therapist.

The remarks on WeBaVeR were mainly about the user interface and interactive capabilities of the web application, and the lack of improvement in health awareness, or accessibility of the patient to health care providers. The comments about the web application are explainable given that the web application focused primarily on being functional and complete, and to a lesser extent aesthetically outstanding. Also, the interactive features are indeed limited. The web application does not remember any data of the users, which on the other hand is conducive to privacy and appreciated by the patients. In terms of accessibility and health awareness, the brochure contains information on the general importance of VRT, and in which symptoms contacting a physician is recommended. Further optimisation of the web application and providing additional information in the brochure should therefore be considered.

Other comments mentioned were that it took some learning before they could get started with WeBaVeR. It is true that in the beginning the patient needs a word of explanation about the different parts of WeBaVeR. This can be a little difficult for patients because concentration problems are common in chronic dizziness [45]. The comment that the exercise period could be longer, that it may provoke uncomfortable feelings, and that it can disrupt the daily routine, is inherent to the pathology of chronic dizziness which requires a long-term and daily approach [5, 46]. Finally, it was reported that WeBaVeR may not be able to serve as a substitute for physical consultations. This could indicate that although exercise therapy at home is useful, the patient might needs adequate supervision to achieve a better therapy result [47].

Thus, telemedicine - with the recent covid-19 pandemic - is getting more attention than ever before [48-50]. The benefits include making healthcare more accessible and reducing patient costs. The potential of telemedicine for vestibular rehabilitation is evidenced by the fact that VRT is still too often difficult to access [7], and that VRT needs to be performed on a daily basis and thus requires high patient commitment [8]. However, there are also concerns about the use of telemedicine in terms of patient safety, ease of use, accessibility and data security, among others [49]. By developing WeBaVeR

398 and evaluating its user experience, we sought to address both these needs from the literature. With
399 the results of this study, WeBaVeR can be further refined to meet the standards of evidence.

400 Both study strengths and weaknesses need to be mentioned. A strength is that not only usability but
401 also acceptability, satisfaction and quality were surveyed [30]. Another strength is that the user
402 experience was evaluated after 6 weeks so that patients had enough time to get acquainted with
403 WeBaVeR. There are also some limitations to the study. Patient recruitment was complicated by the
404 covid-19 pandemic, although the number of patients collected in this study could already be sufficient
405 to obtain reliable information [35]. Another disadvantage is that although all types of chronic dizziness
406 were allowed to be included, it ended up being only patients with PPPD. Nevertheless, patients with
407 PPPD are those who report visually induced dizziness, and thus are a relevant group. A final limitation
408 is that potential influencing factors on user experience (e.g., degree of Internet access, age, duration
409 of dizziness symptoms) were not taken into account.

410

6. Conclusion

412 The results show that WeBaVeR is considered a useful, acceptable, satisfactory and quality therapy
413 method for chronic dizziness. However, there are still optimisation points, especially regarding the user
414 interface and the interactive capabilities of the web application. Next, a randomised trial will be
415 conducted to study its effectiveness on dizziness and imbalance before implementation in practice is
416 possible.

417

7. Acknowledgement

421

8. Summary table

1.	Despite its proven effectiveness for (chronic) dizziness, vestibular rehabilitation therapy (VRT) is underused in primary care settings.
2.	There is a lack of tools to apply customised VRT in the home setting.
3.	WeBaVeR (WEb-Based VEstibular Rehabilitation therapy) allows patients, with the help of a booklet and access to a web application, to perform customized vestibular exercises (including visual desensitization therapy) at home.
4.	Patients with chronic dizziness consider WeBaVeR as useful, acceptable, satisfactory and of good quality.

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9. References

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540 **APPENDIX A**

541 *Patient A - with mild visually induced dizziness*

542 1. Baseline assessment

543 It was determined that **(1)** a mild degree of visually induced dizziness was present (based on the Visual
544 Vertigo Analogue Scale, VVAS, which had a score of 19.6%), **(2)** fast head movements and stooping
545 were important triggers for dizziness (based on the Dizziness Handicap Inventory scale, DHI), **(3)** fast
546 body rotations in stance provoked dizziness (based on the Functional Gait Assessment, FGA), and
547 finally, **(4)** with eyes closed, static balance on a foam required a lot of concentration but succeeds (30s),
548 while Tandem Romberg (17s) and standing on one leg (11s) were more difficult (based on the Static
549 Balance tests, SBS). Mild neck pain was present secondary to the dizziness symptoms.

550 2. Example of the exercise programme for this patient [a]

Week 1-2	*Category Balance* · Static standing with feet together, eyes open, on uneven surface (e.g., slope, cushion) and/or with arm movements (e.g., ball bouncing against wall) · Static standing with the heel of one foot against the side of the caput metatarsale 1 of the other foot (semitandem), eyes open, on flat/uneven surface *Category Movement Habituation* · Slalom between 2 cones at self-selected speed · Sitting upright and quickly picking up an object on the ground right in front of you *Category Gaze Stabilisation* · VOR x1 in seated position with target on white background, both horizontal and vertical head movements. Speed of head movements is increased by 8bpm every 2-4 days as dizziness subsides, until 240bpm is reached. *Category Neck* · Training position sense of the neck with laser light with eyes open/closed (more information, see [51])
Week 3-4	*Category Balance* · Static standing with feet together, eyes closed, on uneven surface (e.g., slope, cushion) and/or with arm movements (e.g., clapping your hands) · Static standing with the heel of one foot against the toes of the other (tandem Romberg), eyes open, on flat/uneven surface *Category Movement Habituation* · Figure 8 stepping between 2 cones at increased speed · Sitting upright, turning the head 45 degrees left/right, then quickly bending the head forward to the knees *Category Gaze Stabilisation* combined with *Category Visual Desensitisation* · VOR x1 in seated position with target on busy background (e.g., patterned floor, stripes), both horizontal, vertical and oblique head movements *Category Neck* · Training motion sense of the neck with laser light (more information, see [51])

Week 5-6	*Category Balance* combined with *Category Visual Desensitisation*
	· Static standing with feet together/semitandem/tandem on an even surface while looking at a busy image (e.g., checkerboard) or video (e.g., supermarket, passing train, moving water)
	· Static standing with heel of one foot against toes of the other (tandem Romberg) with eyes open on uneven surface
	Category Movement Habituation
	· Stepping, quickly turning 180 degrees or 360 degrees, and stepping further
	· In standing position grasping an object on the ground straight/angled in front of you
	Category Gaze Stabilisation
	· VOR x2 in sitting position with moving target on white background, both horizontal and vertical head movements
	Category Neck
	· Neck – Craniocervical flexion training (more information, see [51])

551 ᵃ VOR = vestibulo-ocular reflex

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Patient B - with high visually induced dizziness

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554 1. Baseline assessment

555 It was determined that **(1)** a high degree of visually induced dizziness was present (based on the VVAS
556 which had a score of 83.9%), **(2)** looking up, quick head movements, turning over in bed, walking in the
557 dark, and stooping were important triggers for dizziness (based on the DHI), **(3)** with eyes closed,
558 tandem standing (19s) and standing on one leg (9s) were difficult to perform (based on the SBS), and
559 finally **(4)** horizontal and vertical head movements while stepping, and fast body rotations in stance
560 also trigger dizziness (based on the FGA). There was no neck pain present.

561 2. Example of the exercise programme for this patient

Week 1-2	*Category Balance*
	· Static standing with feet together, eyes closed, on uneven surface (e.g., slope, cushion) and/or with arm movements (e.g., moving the arms quickly sideways)
	· Static standing with the heel of one foot against the side of the caput metatarsale 1 of the other foot (semitandem), eyes open, on flat/uneven ground
	Category Movement Habituation
	· From supine position turning quickly to left/right side position
	· Standing upright and throwing a soft ball straight up and catch it, with the head following the movement of the soft ball
	Category Gaze Stabilisation
	· VOR x1 in seated position with target on white background, with both horizontal and vertical head movements. Speed of head movements is increased by 8bpm every 2-4 days as dizziness subsides, until 240bpm is reached.
	Category Visual Desensitisation
	· Sitting (chair with arm and/or backrest, or stool) or standing upright and looking at realistic images (e.g., patterned floor, fruit basket, bowling alley)

Week 3-4	*Category Balance* · Static standing with the heel of one foot against the toes of the other (tandem Romberg) with eyes open, on flat/uneven surface · Static standing with nodding/shaking head movements with eyes open/closed *Category Movement Habituation* · From side lying right quickly turning to side lying left, and vice versa · Throwing and catching a soft ball in an arc in front of you with both hands, with the head following the movement of the soft ball *Category Gaze Stabilisation* · VOR x1 in seated position with target on white background, both horizontal, vertical and oblique head movements. Speed of head movements is increased by 8bpm every 2-4 days as dizziness subsides, until 240bpm is reached. *Category Visual Desensitisation* · Sitting (chair with arm and/or backrest, or stool) or standing upright and looking at abstract images (e.g., checkerboard, horizontal or vertical stripes)
Week 5-6	*Category Balance* · Static standing on one leg with eyes open, on flat/uneven surface · Walking with nodding/shaking head movements *Category Movement Habituation* · Quickly turning 180 or 270 degrees · Sitting upright and quickly picking up an object on the ground right in front of you *Category Gaze Stabilisation* · VOR x2 in sitting position with moving target on white background, both horizontal and vertical head movements *Category Visual Desensitisation* · Sitting (chair with arm and/or backrest, or stool) or standing upright and looking at realistic/abstract videos (e.g., supermarket, moving water, turning dots, moving stripes, tunnel)

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APPENDIX B

569 ***Table 1***. *Overview of the scores given to each question of the SUS.* [a]

Questions	Mean ± SD
1. I think I would like to use WeBaVeR frequently.	3.83 ± 0.72
2. I found WeBaVeR unnecessarily complex.	1.92 ± 0,67
3. I thought WeBaVeR was easy to use.	4.08 ± 0.90
4. I think that I would need the support of a technical person to be able to use WeBaVeR.	1.33 ± 0.65
5. I found the various parts in WeBaVeR were well integrated.	4.08 ± 0.51
6. I thought there was too much inconsistency in WeBaVeR.	1.58 ± 0.79
7. I would imagine that most people would learn to use WeBaVeR very quickly.	3.92 ± 0.90
8. I found WeBaVeR very awkward to use.	1.92 ± 0.51
9. I felt very confident using WeBaVeR.	4.58 ± 0.51
10. I needed to learn a lot of things before I could get going with WeBaVeR.	2.25 ± 1.36
Total score	78.75 ± 8.95

Each question is accompanied by a 12-cell color bar (numbered 1–12) indicating response distribution.

[a] Legend:
■ strongly agree   ■ moderately agree   ■ neutral   ■ moderately disagree   ■ strongly disagree

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Table 2. *Overview of the scores given to each question of the CSQ.* [a]

Questions	Mean ± SD
1. How do you find the quality of WeBaVeR?	3.25 ± 0.62
2. Was this the kind of help you were hoping to get?	3.33 ± 0.65
3. To what extent has WeBaVeR met your needs?	3.08 ± 0.67
4. If an acquaintance needed the same help, would you recommend our WeBaVeR?	3.50 ± 0.67
5. Overall, did you find the length of the exercise period sufficient?	3.25 ± 1.06
6. Did you feel you were able to practice adequately?	3.33 ± 0.49
7. Did WeBaVeR help you cope better with your problems?	3.25 ± 0.62
8. Overall, how satisfied are you with WeBaVeR you received?	3.42 ± 0.67
9. To what extent was the conclusion of treatment a joint decision between you and the caregiver?	3.17 ± 0.72
10. Suppose you ever seek help again, would you come back to us?	3.50 ± 0.67
Total score	33.08 ± 3.37

(Each question includes a 12-segment scale bar numbered 1–12 colored per the legend below.)

[a] Legend:
■ strongly agree ■ moderately agree ■ moderately disagree ■ strongly disagree

***Table 3**. Overview of the scores given to each question of the SUTAQ.* [a]

Questions	Mean ± SD
Enhanced care (score ranges between 5-30)	*24.58 ± 3.23*
1. WeBaVeR has made me more actively involved in my health	5.00 ± 0.95
2. WeBaVeR allows the people looking after me, to better monitor me and my condition	4.58 ± 1.08
3. WeBaVeR can be/should be recommended to people in a similar condition to mine	5.67 ± 0.49
4. WeBaVeR can certainly be a good addition to my regular health or social care	4.83 ± 1.03
5. WeBaVeR has allowed me to be less concerned about my health and/or social care	4.50 ± 1.45
Increased accessibility (score ranges between 4-24)	*17.00 ± 5.44*
6. WeBaVeR I received has saved me time in that I did not have to visit my GP clinic	4.50 ± 1.83
7. WeBaVeR I received has increased my access to care (health and/or social care professionals)	3.83 ± 1.70
8. WeBaVeR I received has helped me to improve my health	5.17 ± 0.84
9. WeBaVeR has made it easier to get in touch with health and social care professionals	3.50 ± 1.83
Privacy and discomfort (score ranges between 4-24)	*7.33 ± 3.00*
10. WeBaVeR has made me feel uncomfortable, e.g., physically or emotionally	2.17 ± 1.80
11. WeBaVeR I received has invaded my privacy	1.00 ± 0.00
12. WeBaVeR I received has interfered with my everyday routine	3.17 ± 1.59

13. WeBaVeR makes me worried about the confidentiality of the private information being exchanged through it											1.00 ± 0.00	
1	2	3	4	5	6	7	8	9	10	11	12	

Care personnel concerns (score ranges between 3-18) — *4.67 ± 1.78*

14. I am concerned that the person who monitors my status through WeBaVeR, does not know my personal health/social care history											1.00 ± 0.00	
1	2	3	4	5	6	7	8	9	10	11	12	

15. WeBaVeR interferes with the continuity of the care I receive (i.e. I do not see the same care professional each time)											2.08 ± 1.44	
1	2	3	4	5	6	7	8	9	10	11	12	

16. I am concerned about the level of expertise of the individuals who monitor my status via WeBaVeR											1.58 ± 0.67	
1	2	3	4	5	6	7	8	9	10	11	12	

Satisfaction (score ranges between 3-18) — *16.50 ± 2.02*

17. WeBaVeR has been explained to me sufficiently											5.83 ± 0.39	
1	2	3	4	5	6	7	8	9	10	11	12	

18. WeBaVeR can be trusted to work appropriately											5.42 ± 0.79	
1	2	3	4	5	6	7	8	9	10	11	12	

19. I am satisfied with WeBaVeR I received											5.25 ± 0.97	
1	2	3	4	5	6	7	8	9	10	11	12	

WEBAVER as substitution (score ranges between 3-18) — *11.08 ± 3.34*

20. WeBaVeR is not as suitable as regular face to face consultations with the people looking after me											3.50 ± 1.68	
1	2	3	4	5	6	7	8	9	10	11	12	

21. WeBaVeR can be a replacement for my regular health or social care											3.42 ± 1.38	
1	2	3	4	5	6	7	8	9	10	11	12	

22. WeBaVeR has allowed me to be less concerned about my health status											4.17 ± 1.19	
1	2	3	4	5	6	7	8	9	10	11	12	

Total score (score ranges between 22-132)
(scores inverted for 'privacy and discomfort' and 'care personnel concerns') — 105.67 ± 13.40

[a] Legend:
■ strongly agree ■ moderately agree ■ slightly agree ■ slightly disagree ■ moderately disagree ■ strongly disagree

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Table 4. *Overview of the scores given to each question of the uMARS.* [a]

Questions	Mean ± SD
Objective quality (score ranges between 16-80)	*59.83 ± 5.32*
A. Engagement	*17.33 ± 2.50*
1. Entertainment: Is the app fun/entertaining to use? Does it have components that make it more fun than other similar apps?	3.33 ± 0.78
2. Interest: Is the app interesting to use? Does it present its information in an interesting way compared to other similar apps?	4.25 ± 0.62
3. Customisation: Does it allow you to customise the settings and preferences that you would like to (e.g., sound, content and notifications)?	3.50 ± 1.38
4. Interactivity: Does it allow user input, provide feedback, contain prompts (reminders, sharing options, notifications, etc.)?	2.17 ± 0.84
5. Target group: Is the app content (visuals, language, design) appropriate for the target audience?	4.08 ± 0.67
B. Functionality	*15.58 ± 1.88*
6. Performance: How accurately/fast do the app features (functions) and components (buttons/menus) work?	4.00 ± 0.74
7. Ease of use: How easy is it to learn how to use the app; how clear are the menu labels, icons and instructions?	3.92 ± 0.52
8. Navigation: Does moving between screens make sense; Does app have all necessary links between screens?	3.58 ± 0.67
9. Gestural design: Do taps/swipes/pinches/scrolls make sense? Are they consistent across all components/screens?	4.08 ± 0.67
C. Aesthetics	*10.00 ± 2.00*
10. Layout: Is arrangement and size of buttons, icons, menus and content on the screen appropriate?	3.42 ± 1.0
11. Graphics: How high is the quality/resolution of graphics used for buttons, icons, menus and content?	3.50 ± 0.67

12. Visual appeal: How good does the app look? — **3.08 ± 0.67**

1	2	3	4	5	6	7	8	9	10	11	12

D. Information — *16.92 ± 1.44*

13. Quality of information: Is app content correct, well written, and relevant to the goal/topic of the app? — **4.00 ± 0.60**

1	2	3	4	5	6	7	8	9	10	11	12

14. Quantity of information: Is the information within the app comprehensive but concise? — **4.00 ± 0.43**

1	2	3	4	5	6	7	8	9	10	11	12

15. Visual information: Is visual explanation of concepts – through charts/graphs/images/videos, etc. – clear, logical, correct? — **4.17 ± 0.58**

1	2	3	4	5	6	7	8	9	10	11	12

16. Credibility of source: does the information within the app seem to come from a credible source? — **4.75 ± 0.45**

1	2	3	4	5	6	7	8	9	10	11	12

Subjective quality (score ranges between -) — *14.58 ± 2.64*

17. Would you recommend this app to people who might benefit from it? — **4.25 ± 0.62**

1	2	3	4	5	6	7	8	9	10	11	12

18. How many times do you think you would use this app in the next 12 months if it was relevant to you? — **3.83 ± 1.47**

1	2	3	4	5	6	7	8	9	10	11	12

19. Would you pay for this app? — **2.92 ± 1.24**

1	2	3	4	5	6	7	8	9	10	11	12

20. What is your overall (star) rating of the app? — **3.58 ± 0.52**

1	2	3	4	5	6	7	8	9	10	11	12

Perceived impact (score ranges between -) — *20.17 ± 5.20*

21. Awareness – This app has increased my awareness of the importance of addressing the health behaviour — **3.17 ± 1.53**

1	2	3	4	5	6	7	8	9	10	11	12

22. Knowledge – This app has increased my knowledge/understanding of the health behaviour — **3.25 ± 1.22**

1	2	3	4	5	6	7	8	9	10	11	12

23. Attitudes – The app has changed my attitudes toward improving this health behaviour — **3.17 ± 0.94**

1	2	3	4	5	6	7	8	9	10	11	12

24. Intention to change – The app has increased my intentions/motivation to address this health behaviour — **3.58 ± 0.79**

1	2	3	4	5	6	7	8	9	10	11	12

25. Help seeking – This app would encourage me to seek further help to address the health behaviour (if I needed it) 3.75 ± 0.97

1	2	3	4	5	6	7	8	9	10	11	12
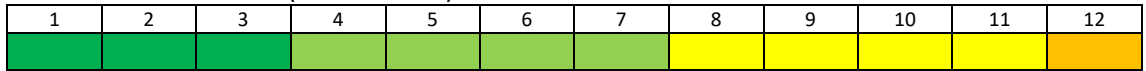
26. Behaviour change – Use of this app will increase/decrease the health behaviour 3.25 ± 0.97

1	2	3	4	5	6	7	8	9	10	11	12

[a] Legend:
■ strongly agree ■ moderately agree ■ neutral ■ moderately disagree ■ strongly disagree

581

582

583