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Table of Contents

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Abstract

Background: The exponential growth of telehealth is revolutionizing healthcare delivery, but its evaluation has not matched the pace of its uptake. Various forms of assessment, from single-item to more-extensive questionnaires, have been used to assess telehealth and digital therapeutics and their usability. The most-frequently used questionnaire is the “Telehealth Usability Questionnaire” (TUQ). The use of the TUQ is limited by its restricted availability in languages other than English and its feasibility.

Objective: The aims of this study were to create a translated German TUQ version and a derived short questionnaire for patients: “Telehealth Usability and Utility Short Questionnaire for patients” (TUUSQ).

Methods: As a first step, the original 21-item TUQ was forward- and back-translated twice. In the second step, 13 TUQ items were selected for their suitability for general evaluation of telehealth on the basis of expert opinion. These 13 items were surveyed in four studies evaluating 13 healthcare applications including digital therapeutics and a telehealth system (n1 = 129; n2 = 220; n3 = 30; n4 = 12). Psychometric exploratory factor analysis was conducted.

Results: The analysis revealed that a parsimonious factor structure with two factors (“healthcare utility” and “usability”) is sufficient to describe the patient’s perception. Consequently, the questionnaire could be shortened to six items without compromising its informativeness.

Conclusions: We provide a linguistically precise German version of the TUQ for assessing the usability and utility of telehealth. Beyond that, we supply a highly feasible short version that is versatile for general use in telehealth, mobile Health and digital therapeutics and which distinguishes between the two factors “healthcare utility” and “usability” in patients. Clinical Trial: No Trial Registration was necessary.

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Keywords: mHealth, telehealth, usability, questionnaire validation, questionnaire translation, net promoter scale, utility

Abstract

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Introduction

Telehealth, mobile Health and Digital Therapeutics

Telehealth is an umbrella term defined as “the provision of healthcare remotely by means of telecommunications technology”, whereas mobile health or mHealth is an overlapping definition for “the use of mobile devices so that patients can solicit services electronically, use apps to verify information, and manage or monitor treatment or problems or other health-related issues” (1,2). The exponential growth of telehealth and mHealth is revolutionizing healthcare delivery, because they have the potential to remove geographical barriers, increase access to medical services, and improve overall care quality (3). Particularly during the COVID-19 pandemic, there was a significant increase in the use of telehealth and mHealth, but the evaluation and its methodology has not matched the pace of its uptake (4,5). Patients can thus receive support throughout the entire patient pathway, including app-supported diagnosis, therapy, and monitoring. Approved digital therapeutics (German: Digitale Gesundheitsanwendungen) are apps to improve treatment and its costs are covered by the statutory health insurance system in Germany. In the following we use “telehealth” to encompass the terms “mHealth” and “digital therapeutics”.

To achieve the greatest possible benefit from telehealth, usability is the key factor, especially with patients who have a cognitive limitation, are incapacitated by their disease, or are children (6). This means that even evidence-based technology is not particularly effective for patient outcomes if it is difficult to use. In addition, measuring usability also protects patients from errors or suffering harm. For example, if a certain telehealth system saves or displays medical data incorrectly and this leads to an incorrect treatment, this inadequate usability can also disadvantage patients (7).

Definition of Usability

The International Standards Organization (ISO) defines usability as: “the extent to which a system, product or service can be used by specified users to achieve specific goals with effectiveness, efficiency and satisfaction in a specified context of use.” (8). However, leading usability researchers such as Dr. Nielsen reported five attributes of usability instead of ISO’s three: learnability, efficiency, memorability, error rate and recovery, and satisfaction (9). Moreover, usability must always be seen in the context of utility so that the overarching usefulness of a technology is identified (10).

Usability Questionnaires

On the one hand, the authors of this study used the single-item “Net Promoter Scale” (NPS) to evaluate telehealth (11,12,13,14). However, the psychometric correlates of the NPS are not clear and

it is also thought to measure satisfaction and acceptance (13). On the other hand, up to 38-item questionnaires were used to measure usability (15). However, many usability questionnaires only measure efficiency and satisfaction (10). Many questionnaires are only available in the English language, have low empirical evidence concerning their psychometric properties, or can only assess the usability of a specific or individual technology (10).

For usability studies in the German language, hardly any validated and appropriate questionnaires are available (16). A small number of questionnaires capture usability-related constructs, but do not focus directly on usability (e.g., MARS-G (17) and the User Experience Questionnaire (18)). The AttrakDiff questionnaire measures usability as merely one dimension among several others (19). There are also questionnaires whose area of application is very limited (e.g., ISONORM 9241/110 on desktop applications (20)). As far as we know, only the German translation of the System Usability Scale – the origin of all usability questionnaires – seems to be available for wider use so far (21). However, none of the existing four different German versions is convincing (22). Altmann et al. published a German version and a short version of the "Telemedicine Perception Questionnaire" (TMPQ) in 2022 (23). The original questionnaire includes 17 items designed to evaluate the patients' impressions of home telecare as well as to assess its potential risks and benefits. Thus, the TMPQ does not measure usability per se and is limited to evaluating older patients receiving video consultation from a nurse. Moreover, the validation of the questionnaire is limited by only 32 and 10 participants in its validation study (24). The German translation could be shortened after subgroup analysis to a short version with five items. The German version of the TMPQ showed sufficient reliability (Cronbach's alpha = 0.76) in Altmann´s study with 32 participants compared to the original study (Cronbach's alpha = 0.8). For the brief version, reliability was still acceptable with Cronbach´s alpha of 0.72. Different authors in this field offered German translations of the mHealth App Usability Questionnaire (MAUQ) (25,26,27). Moorthy et al. validated their translated MAUQ in a specific sample of 133 cancer patients but (presumably due to the small sample size) the factor structure of the translated questionnaire was not further investigated (25). Kopka et al. provided a German version and a German short version in a sample of 148 patients using a symptom checker app in an emergency department in a randomized controlled trial (26). They showed that the original factor structure did not fit the data well, but no further investigation of the factor structure was conducted. In their validation study (n = 53), Tacke et al. showed a strong positive correlation between their MAUQ translation and the SUS (27). However, the factor structure was not examined due to the sample size. Considering the small sample sizes, selective samples, and the lack both of validated translations and of an investigation of the configural factor structure of the questionnaire, there is still a need to develop a German questionnaire to assess the general usability of both telehealth and video consultations in which the factor structure is evaluated on the basis of a sufficiently large data set.

Telehealth Usability Questionnaire (TUQ)

The TUQ by Parmanto et al. in 2016 measures all usability attributes except memorability, allows the evaluation of video consultations, and is the most-used usability questionnaire (28,29,30). The TUQ uses pre-existing items from other questionnaires and is freely available following the Creative Commons license 4.0. The TUQ is recommended by other authors and by frameworks for assessing telehealth (10,13,28,29,30). We therefore translated and validated the TUQ in German. The TUQ contains six domains, which are thought to represent each individual usability factor:

1) usefulness;
2) ease of use and learnability;
3) interface quality;
4) interaction quality;
5) reliability; and
6) satisfaction and future use.

With respect to our initial definition above, the first domain “usefulness” measures utility. The “efficiency” attribute, proposed by Nielsen, aims to assess the “level of attainable productivity of the user after he has learned the system” (9). We see this attribute covered by TUQ item no. 6: “I believe I could become productive quickly using this system “(28,29).

All other attributes are covered in the corresponding domains; however, Nielsen’s “memorability” attribute of usability does not seem to be covered in the TUQ.

The TUQ is a questionnaire of 21 items and has a Likert scale of 1 “strongly disagree” to 7 “strongly agree” as a response option. The usability factors had good reliability (usefulness: Cronbach's alpha = 0.85; ease of use: Cronbach's alpha = 0.93; effectiveness: Cronbach's alpha = 0.87; reliability: Cronbach's alpha = 0.81; satisfaction: Cronbach's alpha = 0.92) (28).

Bibiloni et al. (31) published an exploratory factor analysis (150 questionnaires) of the TUQ (28) relating to video consultation. They found that two factors were sufficient to model the observed data. After the questionnaire was adapted to 12 items by an expert team, a confirmatory factor analysis (269 questionnaires) was performed. Both factors could be measured with good reliability, but they were highly positively correlated. Despite adapting the items and shortening the questionnaire to 12 items, the main problem with the questionnaire was that no good differentiation between usability and utility could be achieved. Although the high factor correlation raised the question of whether respondents differentiate between these two aspects, a one-factor model showed clearly worse fit than the two-factor model. A limit to the application of Bibiloni’s short questionnaire was that the inclusion criteria merely required a single instance of a video consultation and thus does not allow for the general evaluation of apps in telehealth. Besides, as Bibiloni’s factor analysis confirmed, the TUQ measures usability as well as utility, and thus Telehealth Usability Questionnaire continues to be a misnomer.

The primary objective of this study was to develop and validate a German-language version of the TUQ and compare it to the NPS. This adaptation aims to make the TUQ readily accessible and broadly applicable for evaluating telehealth usability within German-speaking populations. The second aim was to reduce the number of items in order to optimize the feasibility for use in general field studies in telehealth, mHealth and digital therapeutics.

Methods

The study had two stages:

Stage I (April 2022-January 2023): Translation, adaptation, and pilot testing of face validity

Stage II (July 2022-September 2023): Development of a short scale: psychometric testing and final item selection

The reporting of this study has been structured according to the STROBE recommendations for observational studies.

Stage I: Translation, Adaptation, and Pilot User Testing

Translation

High-quality translations can only be produced if measurement instruments are linguistically replicated and culturally adapted as rigorously as possible. Sousa and Rojjanasrirat (32) presented a guideline on “Translation, adaptation and validation of instruments or scales for use in cross-cultural health care research”. In agreement with the lead author, Bambang Parmanto, we (MJD, JZ) conducted translation and cross-cultural adaptation with a multidisciplinary expert committee. To include users’ opinions and views on the German version of the TUQ, we conducted pilot testing with medical staff as well as relatives of palliative care children (Figure 1).

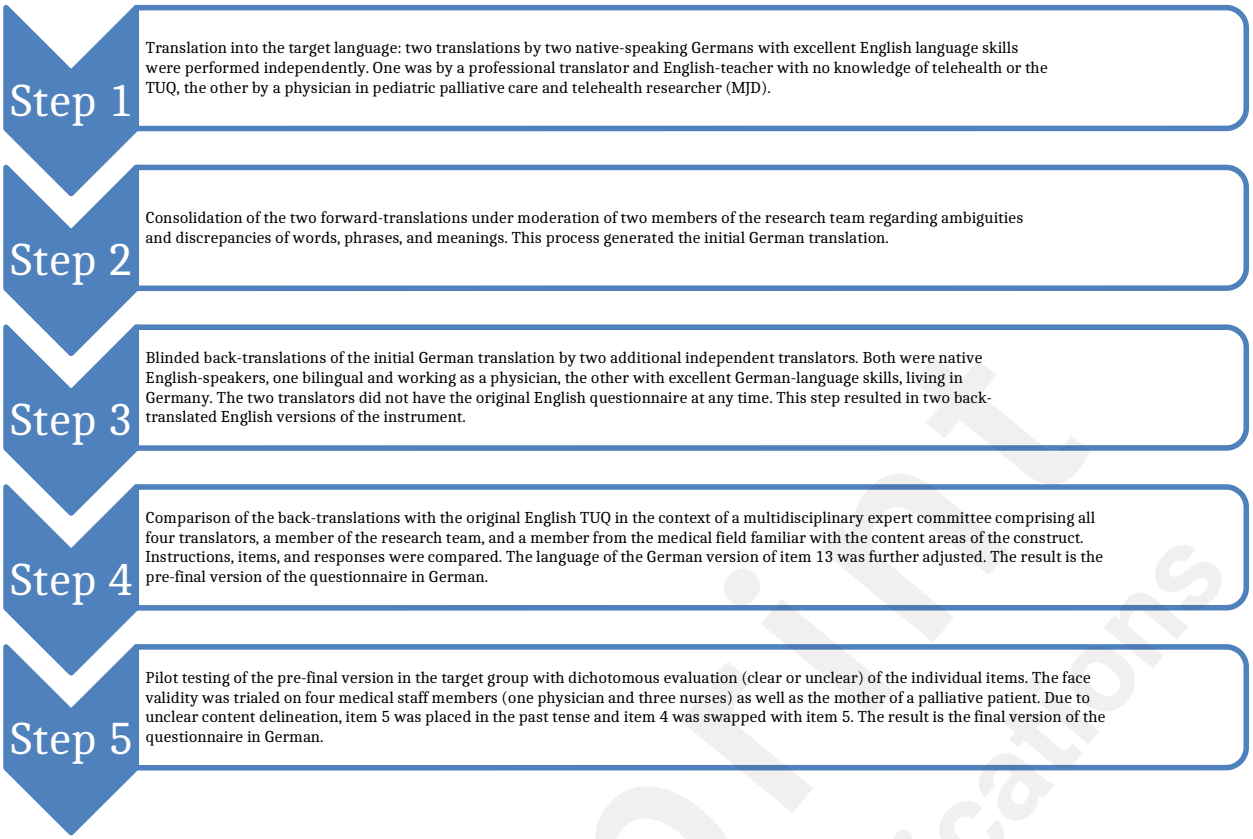

Figure 1. Stage I. The translation process and a pilot user testing.

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Stage II: Development of a Short Scale: Psychometric Testing in Different Target Populations and Final Item Selection

Design and Setting

A prospective observational cohort study was conducted on two sites: Site 1: Assessment of 12 interactive as well as standalone digital therapeutics in the gastroenterology and rheumatology outpatient clinic at the University Hospital Erlangen. Site 2: Assessment of the video consultation and auscultation features of a telemedical system with patients and their parents receiving pediatric palliative home care (PPHC) in the German state of Hesse (33,34). Both sites used modified versions of the TUQ. The survey period was between July 2022 and September 2023. Participation in the survey was voluntary. The study was approved by the institutional review board of the Medical Faculty of the University of Erlangen-Nuremberg, Germany (Reg. no. 22-425-Bm, 25.01.2023), University of Kassel, Germany (Reg. no. 202213, 28.04.2022) and University of Giessen (Reg. no. AZ 64/22, 16.09.2022). All procedures were performed in accordance with relevant guidelines and regulations as well as the Declaration of Helsinki.

Participants and Patients

All patients who took part in the survey on site 1 were part of one of three studies conducted by the outpatient clinic at Erlangen University Hospital and were prescribed one of the 13 digital therapeutics in the period from January to September 2023 (see Supplementary Table 1). All patients who took part in the survey on site 2 were patients with ongoing PPHC. All patients had to first sign the written informed consent. Inclusion criteria for site 1 were a minimum age of 18 years, diagnosis of a rheumatological disease or inflammatory bowel disease (IBD), and a prescribed digital therapeutic. Inclusion criteria for site 2 were ongoing PPHC. Baseline data on demographic characteristics, disease status, and type of digital therapeutics were collected.

Data Collection, Procedures, and Measurement

Baseline data on demographic characteristics, disease status, and usability measured were collected using questionnaires. We calculated mean and *SD* for all results. Patients were asked to complete a TUQ before and after the consultation in the ambulance (site 1) or after the use of the telemedical system (site 2). In addition, on site 1 the single-item NPS (35) was completed. The survey was completed partly on site or online by email using the RedCap data collection system (site 1) or the Unipark data collection system (site 2). Participants were asked “How likely are you to recommend this app to other patients?” and could respond on an 11-point scale ranging from 0 (“Very unlikely”) to 10 (“Very likely”). Depending on the results, patients could be divided into three groups: “promoters” (rating 9 or 10), “neutral” (rating 7 or 8), or “detractors” (rating 0 to 6).

Statistical Analysis

Descriptive statistics were performed using SPSS (Version 27.0; IBM Corp. Released 2020. IBM SPSS Statistics for Windows, Version 27.0. Armonk, NY: IBM Corp.). Exploratory Factor Analyses (EFAs) were conducted in R (Version 4.3.2 (36,37)) using the packages lavaan, semTools, and psych (38,39). The number of factors was determined using parallel analysis (40). EFA models were estimated using full information maximum likelihood information to account for occasional missing values (< 5% per case and item). The initial factor solutions were rotated using an oblique Geomin

rotation with 100 random starts for the gradient projection algorithm (41). The Geomin parameter ϵ was set to 0.001, strongly favoring solutions with lower cross-loadings (42,43,44,45). Based on the initial factor solution, a short scale was developed by removing items in order to achieve a simple structure and refine the substantive interpretation of the factors.

Results

Stage I: Translation, Cross-Cultural Adaptation and Validity

The TUQ was translated in a step-by-step protocol shown in Figure 1. The expert committee discussed several minor cultural and linguistic differences, and the original developer approved all the adjustments. Original TUQ item 4 “It was simple to use this system” was swapped with item 5 “It was easy to learn to use the system”, as multiple pilot user testers were irritated by this pair of questions.

The TUQ questionnaire is designed to assess different types of telehealth and, depending on which technological application is to be assessed, its wording can be adapted accordingly. There was a need to clarify the terms “telehealth”, ‘‘system”, and “telehealth system”, which were all replaced by the term "app" to make the questionnaire applicable to apps. See Table 1 for the complete translation.

Table 1: English and German versions of the TUQ for patients**.** Pilot testing resulted in the following change: item 4 was put in the past tense instead of present tense as shown in the table. Additionally, item 4 was swapped with item 5 (not shown). The translation of the TUQ version for healthcare professionals is available in the supplementary material (Supplementary Table 2).

Item	**Usefulness**	**Nützlichkeit**
1.	Telehealth improves my access to healthcare services.	Die App verbessert meinen Zugang zur Gesundheitsversorgung.
2.	Telehealth saves me time traveling to a hospital or specialist clinic.	Durch die App spare ich Zeit in ein Krankenhaus oder zu einem niedergelassenen Ärzt:in zu fahren.
3.	Telehealth provides for my healthcare needs.	Die App kann mich bei meinen gesundheitlichen Anliegen unterstützen.
	Ease of Use and Learnability	**Benutzerfreundlichkeit und Erlernbarkeit**
4.	It was simple to use this system.	Die App lässt sich einfach bedienen.
5.	It was easy to learn to use the system.	Die Bedienung der App war leicht zu erlernen.
6.	I believe I could become productive quickly using this system	Ich glaube ich könnte die App schnell erfolgreich einsetzen.
	Interface Quality	**Qualität der Benutzeroberfläche**
7.	The way I interact with this system is pleasant.	Die Benutzeroberfläche der App ist angenehm gestaltet.
8.	I like using the system.	Ich bediene die Benutzeroberfläche der App gerne.
9.	The system is simple and easy to understand.	Die Benutzeroberfläche der App ist einfach und leicht zu verstehen.
10.	This system is able to do everything I would want it to be able to do.	Die Bedienung der Benutzeroberfläche ermöglicht alles, was ich von ihr erwarte.
	Interaction Quality	**Qualität der Interaktion**

11.	I could easily talk to the clinician using the telehealth system.	Es war einfach, über die App mit dem Gesundheitspersonal zu sprechen.
12.	I could hear the clinician clearly using the telehealth system.	Über die App konnte ich das Gesundheitspersonal klar und deutlich hören.
13.	I felt I was able to express myself effectively.	Ich hatte den Eindruck, das Gesundheitspersonal hat mein Anliegen verstanden.
14.	Using the telehealth system, I could see the clinician as well as if we met in person.	Über die App konnte ich das Gesundheitspersonal genauso gut sehen, wie bei einem persönlichen Treffen.
	Reliability	**Verlässlichkeit**
15.	I think the visits provided over the telehealth system are the same as in-person visits.	Für mich sind Kontakte über die App gleichwertig mit Hausbesuchen.
16.	Whenever I made a mistake using the system, I could recover easily and quickly.	Wann immer ich einen Fehler bei der Verwendung der App gemacht habe, konnte ich diesen schnell und einfach beheben.
17.	The system gave error messages that clearly told me how to fix problems.	Die Fehlermeldungen der App sind eindeutig und hilfreich beim Lösen von Problemen.
	Satisfaction and Future Use	**Zufriedenheit und künftige Nutzungsabsicht**
18.	I feel comfortable communicating with the clinician using the telehealth system.	Ich fühle mich wohl, wenn ich über die App mit dem Gesundheitspersonal kommuniziere.
19.	Telehealth is an acceptable way to receive healthcare services.	Es ist akzeptabel Gesundheitsversorgung über die App zu erhalten.
20.	I would use telehealth services again.	Ich würde die App wieder benutzen.
21.	Overall, I am satisfied with this telehealth system.	Insgesamt bin ich zufrieden mit der App.

Stage II: Development of a Short Scale: Psychometric Testing and Final-Item Selection

Patient Characteristics

In total, data from 390 patients were collected. 41.2% (160/390) were male and the mean age was 41.79 ± 13.55 years (Supplementary Material: Table 1). All patients used a digital therapeutic where 13 different apps were mentioned except for group 4, which comprised children, adolescents, and young adults with life-limiting illnesses living at home using a telemedical system for video consultation and auscultation (33,34).

Descriptive Statistics, Factor Analysis TUQ, and Construction of a TUQ Short Version for Patients (TUUSQ)

Table 2 provides an overview of the descriptive statistics including the correlations of the items

surveyed.

Table 2: Descriptive statistics and correlations for study variables (two-sided); Pearson correlations. TUQ item-numbering according to Parmanto et al. (28), see Table 1, NPS = Net Promoter Scale. * = p < 0.05; ** = p < 0.01

	Variable	1	2	3	4.	5	6	7	8	9	10	11	12	13	14
	n	390	390	390	390	390	390	390	390	390	390	390	390	390	378
	M	2.82	2.89	2.88	3.18	3.14	2.98	3.21	3.23	3.30	3.44	3.21	2.98	3.06	6.63
	SD	1.71	1.77	1.80	2.43	2.41	2.02	2.23	1.94	1.94	1.71	1.85	2.09	2.00	2.97
1	TUQ 1	-	0.53**	0.83**	0.61**	0.64**	0.75**	0.66**	0.74**	0.56**	0.55**	0.68**	0.79**	0.77**	0.12*
2	TUQ 2		-	0.38**	0.09	0.12*	0.32**	0.13*	0.29**	0.16**	0.25**	0.30**	0.42**	0.33**	0.17**
3	TUQ 3	1		-	0.71**	0.72**	0.81**	0.73**	0.79**	0.63**	0.59**	0.75**	0.84**	0.84**	0.07
4	TUQ 4	390			-	0.97**	0.79**	0.89**	0.85**	0.76**	0.67**	0.71**	0.71**	0.81**	-0.11*
5	TUQ 5	2.82				-	0.80**	0.88**	0.85**	0.76**	0.68**	0.72**	0.72**	0.82**	-0.11*
6	TUQ 6	1.71					-	0.80**	0.84**	0.72**	0.67**	0.74**	0.81**	0.84**	0.03
7	TUQ 7	-						-	0.87**	0.75**	0.68**	0.73**	0.74**	0.84**	-0.11*
8	TUQ 8								-	0.75**	0.67**	0.72**	0.82**	0.87**	0.05
9	TUQ 16	1								-	0.80**	0.65**	0.65**	0.71**	-0.05
10	TUQ 17	390									-	0.67**	0.59**	0.64**	-0.06
11	TUQ 19	2.82										-	0.72**	0.76**	-0.05
12	TUQ 20	1.71											-	0.90**	0.13*
13	TUQ 21	-												-	0.08
14	NPS														-

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Parallel analysis suggested a two-factor solution, i.e., substantially fewer factors than the six factors originally proposed for the questionnaire. We also explored one- and three-factor solutions, but deemed a two-factor solution most plausible from a substantive point of view. The two factors identified in the digital health application analysis represent distinct aspects: (1) healthcare utility – this refers to the app's effectiveness in healthcare, including anticipated future use; and (2) usability – pertaining to the user's experience while operating the app. Both factors explained a substantial proportion of the observed variance (39.8% and 37.2%, respectively) and were positively correlated (r = 0.59). The overall fit of the initial model was good (CFI = 0.95, SRMR = 0.03, RMSEA = 0.13, $^{2}(53) = 385.07$, $p < 0.001$). Further details on the factor loadings and communalities can be found in Supplementary Table 3. However, the initial factor loading solution was characterized by many cross-loadings. We removed all items with high cross-loadings from the model in order to sharpen the interpretation, arriving at a short version with three items per factor. The final version of scale showed excellent fit (CFI = 0.999, SRMR = 0.004, RMSEA = 0.023, $^{2}(53) = 4.86$, $p = 0.302$). The correlation between the factors was 0.80, and the factors explained 41.6% and 40.3% of the total observed variances, respectively. The standardized factor loadings of the final shortened version are displayed in Table 3. The reliability of the factors as estimated by McDonald's ω were good for both factors (usability: 0.86; healthcare utility: 0.89) (46,47). Cronbach's alpha for the factor's usability (0.92) and healthcare utility (0.93) indicates excellent internal consistency.

Table 3: Telehealth usability and utility short questionnaire for patients (TUUSQ) factor loading. English TUQ items according to the German version referring to "the app". Factor loadings for the proposed telehealth usability and utility short questionnaire for patients (TUUSQ). *N* = 390. Factor 1 = healthcare utility, factor 2 = usability. The extraction method was oblique Geomin rotation. Factor loadings above 0.30 are in bold. Adapted from (28).

Item number	Factor loading		Communalities	Attributes
	1	2		
Healthcare utility				
Item no. 1: The app improves my access to healthcare services.	**0.97**	-0.1	0.79	Access to healthcare
Item no. 2: The app provides for my healthcare needs.	**0.91**	0.04	0.88	Healthcare Support
Item no. 3: I would use the app again.	**0.79**	0.14	0.82	Future Intention of Use
Usability				
Item no. 4: It was simple to use the app	-0.06	**0.99**	0.91	Ease of Use
Item no. 5: The way I interact with the app	0.08	**0.8**	0.87	Reliability

is pleasant.		**7**		
Item no. 6: Whenever I made a mistake using the app, I could recover easily and quickly.	0.09	**0.73**	0.65	User Interface Quality

Table 4. History of selected TUQ items. PSSUQ = Post Study System Usability Questionnaire (48), TSQ = Telemedicine Satisfaction Questionnaire (49), and TAM = Technology Acceptance Model (50). The source of the selected TUQ items is shown, as these were originally developed by the authors of the PSSUQ, TSQ, and TAM questionnaires and afterwards included in the TUQ (48,49,50). TUUSQ items 1, 2, and 3 originate from the TSQ, items 4, 5, and 6 from the PSSUQ questionnaire. Items selected by Bibiloni et al. for assessing video consultations also originate from the TAM questionnaire (31).

Item number in TUQ	1	2	3	4	5	7	11	13	14	16	18	19	20	21
Item included in TUUSQ	X		X	X		X				X			X	
item included by Bibiloni et al.	X	X		X	X		X	X	X	X	X	X	X	X
Source of item PSSUQ				X	X	X				X	X	X		X
Source of item TSQ	X	X	X				X	X	X		X	X	X	X
Source of item TAM					X									

The factors identified in the TUQ show very weak correlations with the NPS: healthcare utility and NPS: r = 0.105, usability with NPS: r = -0.112. Furthermore, the NPS shows no correlation to the majority of the TUQ items and very weak correlations to six TUQ items (see Table 2).

The low strength of these correlations makes it very unlikely that the construct measured by the NPS is similar to the constructs measured by the TUQ. To double-check possible relationships between the Net Promoter Scale and the TUQ items, we determined the Net Promoter Score on the basis of the Net Promoter Scale (11) and calculated the Kendall Tau-b coefficients (two-sided). Ten significant negative correlations with small effect size (51) resulted: between item 3 to 11 with a range of r = -0.10 to r = -0.19.

Discussion

Stage I: Complete TUQ Now Available in German in a High-Quality Translation

The complete TUQ was translated into German and cross-culturally adapted. It is comprehensible and equivalent to the English version (28; Table 1).

Stage II: Development of the Telehealth Usability and Utility Short Questionnaire for Patients (TUUSQ)

Factor Structure

The TUQ shows a two-factor structure: on the one hand “usability”, on the other hand “healthcare utility”. Both factors correlate highly positively (r = 0.59). The same factors were also shown as main factors of the Spanish version of the TUQ by the working group of Bibiloni in 2020 (31). A factor analysis of the Thai version of the TUQ also resulted in a two-factor model, comparable both to our study and Bibiloni et al. (52). The two factors were “accessibility” and “utility”. To the best of our knowledge, no further data on the TUQ factor structure were found in other studies (29).

We removed all TUQ items (items 2, 4, 6, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19, 21) with high cross-loadings in order to sharpen the interpretation, arriving at a short version with three items per factor (Table 3). As the TUQ, similar to many other usability questionnaires, also contains items measuring

utility, we therefore propose a clear title stating the dual purpose of the short questionnaire, thus "Telehealth Usability and Utility Short Questionnaire for Patients" (TUUSQ). Bibiloni et al. proposed a short version with 12 items to assess usability in telehealth focusing on video consultations. This short version shares four items with the TUUSQ.

Factor Healthcare Utility

The factor that we named "healthcare utility" was included in the TUUSQ with two items relating to healthcare access and support. In addition, one item regarding the intention of future use (Cronbach's alpha = 0.79) loads this factor. As this intention of [future] use relates to digital healthcare and not, as might be thought by some users, to certain popular entertainment apps, we interpret this finding as follows: the future intention of use aggregates to the factor of utility in healthcare support. Other studies in other contexts also demonstrated that satisfaction and future intention of use show high correlation (53,54,55,56).

Factor Usability

The second factor "usability" contains one item each regarding learnability, reliability, and interface quality. The TUUSQ thus lacks the TUQ items addressing the usability attributes as defined by Nielsen, i.e., "efficiency" (item 6), "efficacy" (item 2) and "satisfaction" (item 21) (9). However, as our data show no benefit in adding further items and the feasibility of a six-item questionnaire is very good, we advocate this short version. Interestingly, in contrast to the above-mentioned usability attributes, the TUQ item addressing interface quality showed the second-highest factor loading for the factor usability in our study. One of the first usability questionnaires, the "Post Study System Usability Questionnaire" (PSSUQ) showed a three-factor model with the factors "interface quality", "system usefulness", and "information quality" (48). Saeed et al. (57) also showed that, in the context of telehealth home monitoring, the quality of the user interface is of utmost importance for patient usability.

This finding was also present in usability studies in other healthcare settings (58).

The original TUQ contains no items regarding memorability. We decided against adding an item to assess memorability as our study design does not allow testing for memorability, i.e., ease of re-usability of the applications after long periods of disuse. Of course, the usefulness of telehealth should be memorable and practical in the longer term, but this question was not part of the current study. Further studies on this with a more extended use of telehealth should be carried out in the future.

Net Promoter Scale

Interestingly, the NPS did not show moderate to strong correlations with either the two identified factors (healthcare utility and NPS: 0.105; usability with NPS: -0.112) or with any of the individual TUQ items. These results show that the NPS is not suitable for assessing any of the patient's usability or healthcare utility attributes covered by the TUQ in our studies. As the TUQ contains an item to assess satisfaction (item 21), our studies support the findings of Krol et al. that the NPS does not measure patient satisfaction (11). We believe that single-item measures are notoriously unreliable – potentially explaining this null finding – and should not be used as a critical variable in high-stakes settings. The construct which is measured by the NPS in healthcare remains elusive.

Origin and Quality of TUUSQ Items

The items selected from the TUQ for the TUUSQ originate from the PSSUQ and TSQ questionnaires (Tables 3 and 4 (48,49)). All TUUSQ items addressing usability originate from the PSSUQ. The PSSUQ was reviewed by Sousa et al. in 2017 (10) and assessed as one of the best available usability questionnaires, although the TUQ was not included in this study (28). The PSSUQ's items were generated using an empirical study and showed very good internal consistency (Cronbach's alpha = 0.97). However, the quality assessment of validity, reliability, user-centeredness, sample size, and feasibility by Sousa et al. yielded a medium-quality score due to low sample size and lack of reported user-centeredness during item generation (32). The PSSUQ is also sensitive to user-group and system differences (48).

The TUUSQ items assessing healthcare utility all originate from the “Telehealth Satisfaction Questionnaire” (TSQ). The TSQ shows a three-factor model (49) and all items used by the TUQ and thus TUUSQ belong to the factor called “quality of care provided”. No review of the psychometric properties of the TSQ is available. Reported sample size was low and lacked reported user-centeredness but showed good internal consistency (Cronbach's alpha = 0.93).

Limitations

The development of the TUUSQ short questionnaire was for the main part only examined in patients who received digital therapeutics or used a telehealth system. Further studies are needed to evaluate whether the short questionnaire can be successfully applied more widely in the area of telehealth.

Conclusions

The TUUSQ offers a short and high feasible questionnaire for assessing and distinguishing utility and usability of telehealth. The TUUSQ contains solely generalizable items which allow for its use in many different telehealth contexts, as advocated by Sousa et al. (10). Following our study, the TUUSQ can be used in Danish, German, Portuguese, Slovene, Thai, and Urdu, as validated TUQ translations are available for these languages (28,52,59,60). The TUUSQ is free for commercial and non-commercial use following the Creative Commons license 4.0 (61). If, besides healthcare utility and usability, the quality of the video connection during a video consultation as well as the suitability of this medium are of interest to the researchers, we recommend using the TUQ short version as proposed by Bibiloni et al. (31).

Supplementary Material

Supplementary Table 1: Characteristics of participating patients
Supplementary Table 2: German Telehealth Usability Questionnaire version for healthcare professionals
Supplementary Table 3: Results from a Factor Analysis of the Telehealth Usability Questionnaire

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Authors’ Contributions

MJD, JZ, HM, and FS wrote the draft manuscript. FS, JZ, and MJD performed the statistical analysis. Translations were conducted by MD and JZ. Studies were conducted by TO (study 1), JK (study 2), HM (study 3), and MJD and JZ (study 4). All authors reviewed the draft and provided comments for change. All authors approved the final manuscript.

Conflicts of Interest

The authors report no conflicts of interest related to this study. None declared.

Abbreviations:

App: Application
CFI: Comparative Fit Index
COVID-19: Coronavirus-SARS-Co-V-2
EFA: Exploratory Factor Analysis
IBD: Inflammatory Bowel Disease
ISO: International Standards Organization
MARS-G: Mobile App Rating Scale – German

MAUQ: mHealth App Usability Questionnaire
mHealth: mobile Health
NPS: Net Promoter Scale
PPHC: pediatric palliative home care
PSSUQ: Post Study System Usability Questionnaire
RMSEA: Root Mean Square Error of Approximation
SD: Standard Deviation
SRMR: Standardized Root Mean Square Residual
STROBE: Strengthening the Reporting of Observational Studies in Epidemiology
TAM: Technology Acceptance Model
TMPQ: Telemedicine Perception Questionnaire
TSQ: Telemedicine Satisfaction Questionnaire
TUQ: Telehealth Usability Questionnaire
TUUSQ: Telehealth Usability and Utility Short Questionnaire for patients

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Supplementary Files

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Figures

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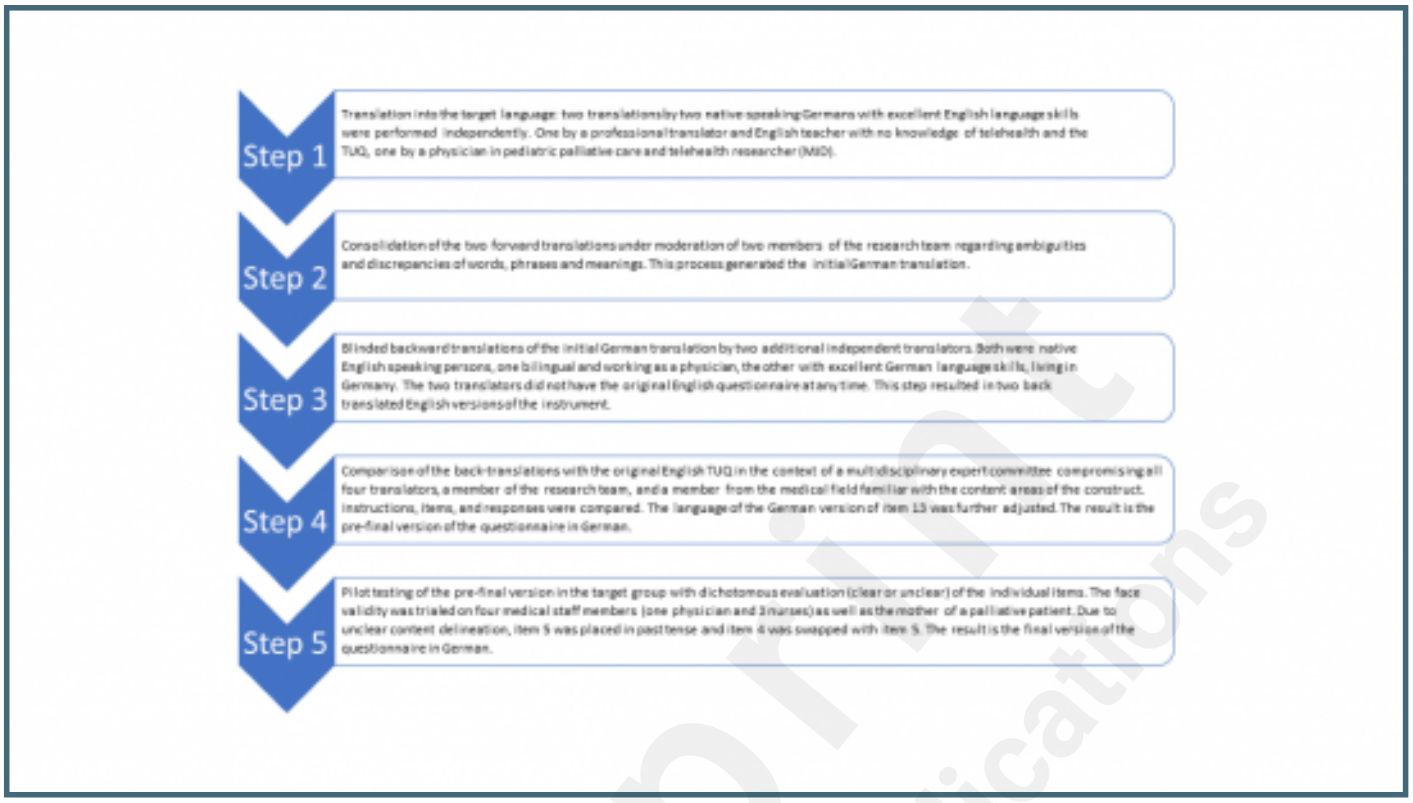
Stage I. The translation process and a pilot user testing.



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Multimedia Appendixes

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Characteristics of participating patients (mean ± SD or n (%)).
URL: http://asset.jmir.pub/assets/33857f80d193c583595089fe005e1a75.docx

German Telehealth Usability Questionnaire version for healthcare professionals.
URL: http://asset.jmir.pub/assets/938ce464f7feac1039f1ddaac39e9d01.docx

Results from a Factor Analysis of the Telehealth Usability Questionnaire (TUQ) N = 390. The extraction method was oblique Geomin rotation. Factor loadings above 0.30 are in bold. Adapted from (28).
URL: http://asset.jmir.pub/assets/621da835ffee13bd5482c86215101dfa.docx

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