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Psychometric properties of a self-assessment questionnaire concerning symptoms and impairment in urinary tract infections: the UTI-SIQ-8

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Abstract

Objectives To validate the UTI Symptom and Impairment Questionnaire (UTI-SIQ-8), a questionnaire that consists of 4 items to assess the symptom severity for dysuria, urgency, frequency, and low abdominal pain, and 4 items to assess the resulting impairment of activity by urinary tract infections (UTI).

Design Prospective observation study.

Setting German primary care practices.

Participants An unselected population of women with UTI. Women could participate online via a mobile health application for smartphones, smartwatches, and tablets or use a paper-and-pencil version.

Main outcomes Psychometric properties of the UTI-SIQ-8 regarding reliability, validity, and sensitivity to change by utilizing factor analysis, and multilevel and network analysis.

Results Data from 120 women with a total of 769 symptom reports across seven days of measurement were analysed. The majority of the participating patients (87/120) used the mobile application via smartphones. The reliability of the UTI-SIQ-8 was high, with Cronbach's alpha of .89 at intake; convergent and discriminant validity was satisfactory. Intraclass correlation demonstrated high sensitivity to change, with 68 per cent of the total variance being due to time differences. These daily changes in an individual's symptoms moved parallel with daily changes in the EQ-5D-5L ($b = 1.68$, $SE = 0.12$, $p < .001$) and the VAS ($b = 0.03$, $SE = 0.003$, $p < .001$), also highlighting convergent validity with respect to daily changes in symptom severity.

Conclusions The UTI-SIQ-8 questionnaire demonstrated high reliability, satisfactory convergent and discriminant validity, and high sensitivity to change in women with uncomplicated UTI. The participants primarily used the mobile application to gain access to the questionnaire. These findings may encourage primary care physicians to use the UTI-SIQ-8 in their daily practice and researchers to apply it to studies involving patients with uncomplicated UTI.

Word count: 286

Keywords: Urinary Tract Infection, Psychometrics, Surveys and Questionnaires, Quality of Life, Symptom Assessment, Primary Health Care

Strengths and limitations of this study

► As we followed patients in their daily life on a day to day basis, our study is highly ecologically valid which makes the UTI-SIQ-8 relevant for primary care physicians to use it in their daily practice and researchers to apply it to studies involving patients with uncomplicated UTI.

► The diary-design of this study and the use of an online app allowed us to collect more than 750 data entries throughout the study highlighting the statistical power of our analyses.

► Using network analyses is novel in UTI research and may give direction to future research for validating self-report questionnaires.

► The UTI-SIQ-8 questionnaire is deliberately kept short to ensure a feasible implementation in daily use.

► At present, we do not advise users to utilize the UTI-SIQ-8 for individual assessment because norm values or reference values are not yet available.

BACKGROUND

Urinary tract infections (UTIs) are common in primary care and encompass a considerable burden of symptoms for affected patients (1, 2). UTI occurs in women more often than men and the typical signs are urgency, frequency and dysuria, often accompanied by low abdominal or back pain, smelly urine, haematuria and pyuria (3, 4). From the women's perspective, particularly concerning symptom severity, the impairment and the impact on daily activities are of high relevance (4, 5).

While the initial symptoms of a UTI are essential for a diagnosis, the course of symptoms, especially in the first few days, is essential to evaluate the clinical effectiveness of treatment. Accordingly, randomised controlled trials (RCTs) in this discipline use questionnaires to inform about the severity of the symptoms at onset and along the course of a UTI (6–10).

There are a couple of symptom questionnaires in use (11–15), most of them in English, but some were translated and validated in other languages, such as Norwegian (6), Chinese (16) or German (7, 17). Most questionnaires were developed for and validated in RCTs. However, transferability in usual care may be limited due to a selection process in RCTs. Some of the symptom questionnaires focused on the severity of UTI symptoms only (6, 8, 18), while others considered the impact of UTI on everyday activities (12). Also, some validation studies were concerned with both aspects (11, 19), but only a handful assessed a questionnaire's sensitivity to change apart from a proper diagnosis (17, 20). With a proper assessment of symptoms, as well as responsiveness or sensitivity to change, the Urinary Tract Infection Symptom Assessment (UTISA) (11) and the Current Acute Cystitis Symptom Score Questionnaire (ACSS) (19) appeared to be well-suited for primary care patients. The authors of both expected the participating women to fill in a rather large questionnaire, comprising 14 or 18-items divided by short intervals. In clinical settings, however, there is a clear need to lower the burden upon patients, especially to follow-up the course of the condition daily. Moreover, questionnaires suitable for modern surveillance technologies increase their applicability (21). A short questionnaire was previously used in two RCTs, ICUTI and REGATTA, to assess symptom severity and

activity impairment in women with uncomplicated UTI (5, 22); however, it was not validated in the targeted population.

Hence, the present study aimed to validate this short self-report questionnaire to measure symptom severity and activity impairment by urinary tract infections and its course—called the UTI Symptom and Impairment Questionnaire, UTI-SIQ-8—in an unselected population of women with UTI in German primary care. An additional objective was to prove the applicability of a mobile application among participating women.

METHODS

The study was performed from November 2016 to May 2018. Ethics approval was obtained from the ethics committee of Göttingen Medical School (17/4/16).

Participants

We invited 298 primary care physicians (i.e., general practitioners and community gynaecologists) in Germany to achieve a sample of approximately 20 practices. All participating physicians provided written informed consent. Women, 18 years and older, with a suspected uncomplicated UTI (with dysuria, urgency, frequency and low abdominal pain), were invited to participate. Women with signs of a complicated infection were excluded. Participants, who gave informed consent received an electronic code that allowed them to access a daily electronic questionnaire for the following 7 days. For more details, refer to (23).

Data collection

All participating women completed a baseline data sheet in the practice with demographic and medical history details.

Each woman was asked to complete the UTI-SIQ-8 questionnaire at inclusion and for 7 days consecutively. Besides, women completed the King's Health Questionnaire (KHQ_G) for assessing the quality of life in women with urinary incontinence, the EQ-5D, to measure the health-related quality of life and a visual analogue scale (VAS) for rating pain. The questionnaires in the study were used for self-assessment either at inclusion only (KHQ_G) or also for the following 7 days (UTI-SIQ-8, VAS pain scale, EQ-5D).

Women could enter their data online via a mobile health application for smartphones, smartwatches, and tablets, including a gentle daily reminder to fill in the questionnaires. Online data collection was realised by a specifically programmed, responsive, dynamic web form. Data transmission was always ensured to be encrypted via SSL/HTTPS. All personal data stored in the relational MySQL database was encoded via symmetric salted cryptography algorithms. All survey data was stored in separate

data tables and allocated using only an anonymized participant-id. Moreover, regarding data export, the participant-id was additionally scrambled, rendering the matching of survey data to personal information practically impossible (see Appendix 1). It was also possible to use a paper-and-pecil version.

Questionnaires

The* UTI-SIQ-8 *Questionnaire. The questionnaire consists of 4 items to assess the symptom severity for dysuria, urgency, frequency and low abdominal pain. These items were scored from 1 (no symptoms at all) to 5 (very strong symptoms) and 4 items to assess the impairment of activity by these symptoms scored from 1 (no impairment at all) to 5 (very strong impairment). The items for the symptom severity scale were developed following the scores used in previous RCTs on UTI treatment (18, 24) and the items for activity impairment scale were translated from the Activity Impairment Assessment score (11, 12). The original questionnaire and an English translation can be seen in Appendix 2.

King's Health Questionnaire, German version (KHQ_G). The KHQ is a self-administered questionnaire designed to assess the impact of urinary incontinence on quality of life. The measure was originally designed for use in women and contains 32 questions, which are scored in 10 domains. Weighted summary scores in each domain range from 0 to 100, with higher scores indicating greater impairment. The KHQ has been validated for use in assessing women with urinary problems, such as an overactive bladder (22, 25). A German version (KHQ_G) has also been validated (15).

EQ-5D-5L. We used a validated German version of the EQ-5D-5L (hereafter abbreviated as EQ-5D), which evaluates the generic quality of life and comprises five dimensions (= 5D), each describing a different aspect of a patient's health status : mobility, self-care, usual activities, pain/discomfort and anxiety/depression, with a 5-level (= 5 L) answer format (26).

Visual analogue scale for pain. We used a simple numeric-geometric scale (VAS) to assess pain. It was developed and validated for use in clinical practice (27).

Statistical analysis

The UTI-SIQ-8 was evaluated in 7 steps:

Item analysis. Mean scores, standard deviations (SDs), and ranges were analysed to evaluate item- and scale score distributions, especially to check for floor and ceiling effects.

Reliability. We determined Cronbach's alpha as a measure of internal consistency based on the intercorrelations among the test items.

Convergent validity. Convergent validity was assessed in terms of the strength of the associations between the UTI-SIQ-8 scores and the EQ-5D pain and activity scores and the VAS.

Discriminant validity. Discriminant validity was investigated by comparing UTI-SIQ-8 items and those EQ-5D and KHQ items that should measure distinct dimensions. For example, we expected that the KHQ incontinence item was only moderately correlated with the UTI-SIQ-8 total score.

Factorial validity. To explore the factorial structure and to check potential cross-loadings of the items, we ran a principal component analysis using Promax rotation, as we expected the influence of correlated factors. We used the scree-plot, the Kaiser criterion, and parallel analysis (28) as criteria to decide how many factors to extract. However, because the scree-plot criterion is somewhat subjective, and using the Kaiser criterion can render us susceptible to overestimating the number of factors, we used O'Connor' syntax (29) and ran a parallel analysis (28) to determine objective and reliable indices for factor extraction.

Sensitivity to change. To investigate sensitivity to change, we analysed whether changes across days in the UTI-SIQ-8 scores were associated with changes in quality of life (EQ-5D) and pain (VAS). To account for the hierarchical data structure, we used multilevel random coefficient modelling (30) with the R-package lme4 (31). Days (level 1) were nested within individuals (level 2). Two separate models were run to examine the co-variability between the quality of life (pain) and symptom severity measured via UTI-SIQ-8. To improve the interpretability of the model results, the predictor variables were group-mean centred before running the models. We also determined the intraclass

correlation (ICC) as an indicator of the sensitivity to change of the UTI-SIQ-8. This process was mandated to determine the degree of changes expected in the UTI-SIQ-8 scores, which could be attributed to differences across days versus differences among people.

Network analysis. To determine the relative position of UTI-SIQ-8 among other theoretically relevant constructs of symptom severity and to further establish convergent and discriminant validity, we examined distinctive associations between the total score of the UTI-SIQ-8 and the measures of quality of life regarding autonomy and pain (both EQ-5D), pain (VAS), and impairment due to incontinence and impairment of personal relationships (both KHQ-G) by using network analysis. The novel approach of network analysis facilitates visualization, description, and significance testing of relations between variables while controlling for the influence of other variables. In network analysis, variables are called *nodes* and relations between variables are called *edges*. In the present analyses, we entered the UTI-SIQ-8 scale score, quality of life regarding autonomy and pain, pain (VAS), and impairment due to incontinence and impairment of personal relationships as the observed *nodes* of the network. *Edges* may be described as partial correlations controlling for all other relationships in the network (r_p). Network analyses were conducted using the R packages qgraph (32) and bootnet (31). The analyses followed suggestions from Epskamp and colleagues (33). To address potential difficulties of interpretation, we followed the conservative way of regularization and interpretation.

Sample size calculation

One aim of the REGATTA trial (22) was to validate a new symptom questionnaire that we planned to use for this trial, especially with regards to its sensitivity to change. We first calculated a sample size of more than 200 patients to have enough statistical power for latent variable models to detect change. Since it proved difficult to reach such a sample size in busy primary care practices, we made use of multilevel models on basis of a high number of data entries and manifest variables that ensured the statistical power of our analysis to detect change.

Patient and public involvement

Patients and public were not involved in the planning and design of this study. All participants who were included in the study gave written informed consent after a thorough explanation of the procedures involved.

RESULTS

Patient characteristics

A total of 18 practices took part in the study, and 131 women were included. We excluded 11 patients due to screening failure or technical reasons, such as missing or erroneous data, resulting in a valid sample of 120 women with a total of 769 symptom reports across 7 days of measurement. The mean age was 43.3 ± 16.6 years, the urine dipstick was positive for leucocytes in 92%, erythrocytes in 87%, and nitrites in 23% and the urine culture was positive in 82% (96/118). Escherichia coli was found in 78% (74/96) of the positive urine cultures. Detailed information on the patient characteristics is reported in (23).

The majority of the participating patients (87/120) used the mobile application via smartphone.

Item analysis

Table 1 shows the mean scores and SDs, as well as further statistical characteristics of the 8 items of the UTI-SIQ-8 for the first 2 days, as reported by the women. They made use of the full scale (1 to 5) for all items on both days (Table 1), resulting in high SDs (1.0 to 1.79). The coefficients for skewness ranged from .048 to .466 on day 0, indicating a low level of skewness, and were somewhat higher on day 1. The mean scores strongly decreased from day 0 to day 1, indicating a sharp decline in symptom severity and activity impairment. The distribution of the items on the following days was more positively skewed as most patients substantially recovered within a few days.

Insert Table 1 here

Reliability

Cronbach's alpha for the 8 items was high on day 0 (.86) and even higher on day 1 (.91), confirming the internal consistency of the UTI-SIQ-8. Notably, 6 items contributed equally to the reliability of the scale and only 2 (abdominal) pain items did not correlate as high as the other items with the total score (Table 2).

Insert Table 2 here

Validity

Factorial validity. Preliminary results revealed one or three factors based on the conventional scree-plot criterion and three factors based on the Kaiser criterion. A parallel analysis, which provides more objective and reliable indices for factor extraction, highlighted two factors (Table 3). The two-factor solution explained 74% of total item variance and confirmed the special role of the two pain items as already detected by the corrected item-total correlations for the reliability analysis. While 6 of the items, referring to urgency, dysuria, and frequency, loaded high on one factor, both pain items loaded on a second factor. However, since Cronbach's alpha was satisfactory for all 8 items and all factors should consist of more than 2 items, we decided to use a one-factor solution as suggested by the scree-plot criterion for the following analyses.

Insert Table 3 here

Convergent validity. The UTI-SIQ-8 was significantly and positively correlated with the pain and activity subscales of the EQ-5D and the VAS (Table 4), confirming convergent validity.

Insert Table 4 here

Discriminant validity. The correlations between the UTI-SIQ-8 and impairment due to incontinence as well as the activity subscale of the EQ-5D were smaller than the convergent validity correlations, exemplifying discriminant validity (Table 4).

Sensitivity to change

The intraclass correlation (ICC = .32) indicates that 32 per cent of the total variance in the UTI-SIQ-8 scores were due to differences between the women and 68 per cent due to time differences. Differences between the item scores can be explained from daily changes in a person's symptoms, which highlights the sensitivity to change of the UTI-SIQ-8. Importantly, these daily changes in an individual's symptoms moved parallel with daily changes in the EQ-5D ($b = 1.68$, $SE = 0.12$, $p < .001$)

and the VAS (b = 0.03, SE = 0.003, p < .001), thus highlighting convergent validity with respect to daily changes in symptom severity.

Network analysis

Figure 1 visualizes the estimated network of the UTI-SIQ-8. The UTI-SIQ-8 takes a central position between the VAS and some of the selected subscales of the EQ-5D and KHQ-G. Symptom severity, as assessed with the UTI-SIQ-8, exhibited a unique connection with pain as assessed with the VAS (r_p = .34) and, to a smaller extent, with impairment in personal relationships (KHQ-G; r_p = .25) and usual activities and pain/discomfort (EQ-5D; r_p = .20). Symptom severity (UTI-SIQ-8) was only slightly related to impairment due to incontinence (KHQ-G, r_p = .14) and negatively related to mobility, self-care, and anxiety/depression (EQ-5D; r_p = -.19).

Insert Figure 1 here

DISCUSSION

The UTI-SIQ-8 proved to be a reliable and valid questionnaire to measure symptom severity and activity impairment and the symptom course in women with UTI in German primary care. Women made use of the full scale of the 8 items to assess the severity of their symptoms and the resulting impairment. Reliability was high, with a Cronbach's alpha of around 0.9; convergent and divergent validity were also satisfactory. The daily changes in a woman's assessment of her symptoms moved parallel to the EQ-5D scores and the VAS for pain, underlining the convergent validity of the questionnaire for sensitivity to change. Network analysis showed a central position of the UTI-SIQ-8 between other measures of pain and the quality of life questionnaires (KHQ_G and EQ-5D). The mobile application was the women's preferred form to complete the questionnaire.

Strengths and limitations

The validation study was conducted separately from the REGATTA trial (5, 22) to mitigate the risk of a selection bias, which is more likely in an RCT. We used different validation methods to demonstrate all relevant forms of validity and to inform future users about applicability. Participating women had to complete a myriad of questionnaires but the UTI-SIQ-8 questionnaire is deliberately kept short to ensure a feasible implementation in daily use.

Our study was highly ecologically valid, as we followed patients in their daily life on a day to day basis. Because of the diary-design of this study and the use of an online app, we were able to collect more than 750 data entries throughout the study highlighting the statistical power of our analyses. Using network analyses (32) is novel in UTI research and may give direction to future research. For example, our research provided evidence that symptom severity, as assessed with the UTI-SIQ-8, takes a central position between the VAS and some of the selected subscales of the EQ-5D and KHQ-G supporting construct validity of our instrument.

Although the design of the study required only a small sample size of participating patients, the data suggest that the study population was comparable to other UTI studies in Germany. For example, a

positive urine culture (approx. 75%), prevalent among women with E. coli infections, and the susceptibility data were analogous with the results of other observational studies in Germany and RCTs (5–7, 25, 34, 35).

At present, we do not advise users to utilize the UTI-SIQ-8 for individual assessment because norm values or reference values are not yet available. Still, the questionnaire revealed satisfactory to good psychometric properties and it can thus be strongly recommended to use the UTI-SIQ-8 in research.

Comparison with existing literature

Similar to the UTISA questionnaire (11), the UTI-SIQ-8 allowed women to rate the different UTI-related symptoms according to their severity and activity impairment. Both studies found that the severity and activity impairment items loaded on the same factor. In other words, if a woman perceived a UTI-symptom as severe, it also strongly affected her everyday life and vice versa. However, the authors of the UTISA decided after analysis to determine 'urination regularity' and 'problems with urination' as two different factors, as they did for pain symptoms. Our analysis inspired us to merge these items and we feel that the one-factor solution is logical, straightforward, and allows a rapid and simple assessment of UTI symptoms and change across days.

Another self-reporting questionnaire, the Acute Cystitis Symptom Score (ACSS) (19), translated in many languages, also proved to be highly reliable and sensitive to change. While the 18-items questionnaire aims to assess the symptom severity and quality of life, in the first and the follow-up consultation, the UTI-SIQ-8 aims to assess the symptom severity and the direct impact of the symptoms on everyday life on a day by day basis. This feature allows sensible monitoring of the symptom course as shown by several studies (6–8). Furthermore, these studies used a symptom diary, which was developed for RCTs to assess the UTI symptom at inclusion and to follow-up the symptom course and duration. The diary was validated for acute lower respiratory tract infections and showed good reliability and sensitivity to change but not for UTI. While it was unclear whether

the results of the validation study are transferable to UTI patients, our analysis confirms the validity of this diary-based symptom assessment.

The items for low abdominal pain did not correlate as high as the other items with the total score of the UTI-SIQ-8. Low abdominal pain does not seem closely linked with the remaining symptoms, namely urgency, frequency and dysuria, in women with acute UTI. This finding is remarkable since low abdominal pain is part of several scores and diaries (5, 8, 11, 19), but we do not know of any studies that made the special role of low abdominal pain a subject of discussion. From the clinical perspective, low abdominal pain is not specific for UTI and can be a symptom for other conditions, like dysmenorrhea or gastroenteritis. It was less frequently present in women with UTI than the other symptoms and there are also other non-specific symptoms associated, such as low back pain or inguinal pain (4), poor concentration or tiredness. However, since low back pain may be relevant at least for a subgroup of women, we decided to maintain this item as one aspect of the UTI-SIQ-8.

Implications for practice and further research

The UTI-SIQ-8 could be used for the baseline assessment of symptom severity in women with uncomplicated UTI and to follow-up the course of the symptoms and their duration on a day by day basis. Therefore, the questionnaire could be used in RCTs to monitor treatment success and make changes in the treatment, if needed. A mobile health application could help to detect patients with worsening symptoms of complications, as demonstrated for other conditions (36).

Conclusions

The present findings support the UTI-SIQ-8 questionnaire as an economic, reliable, and valid instrument for the assessment of symptom severity and symptom change in women with uncomplicated UTI. These findings may encourage primary care physicians to use it in their daily practice and researchers to apply it to studies involving patients with uncomplicated UTI.

Declarations

Ethical approval

The ethics committee of Göttingen Medical School approved the study (17/4/16). All participating physicians and patients provided written informed consent.

Consent for publication

Not applicable.

Availability of data and materials

The data used for the current study are available from the corresponding author on reasonable request.

Conflict of interest

The authors have nothing to disclose.

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Authors' contributions

IG had the initial study idea; all authors worked out the final design of the study. SSP collected the data. KR performed all statistical analyses. IG and WH were the major contributors in writing the manuscript and are the guarantors of the paper. All authors read, discussed, and approved the final manuscript.

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Table 1. Distribution of responses to each UTI-SIQ-8 item

	Day; m (SD)				
Item *	Mean	SD	Min	max	skewness
Day 0					
Urgency	3.37	1.07	1	5	-.45
Dysuria	2.75	1.34	1	5	.05
Frequency	3.35	1.09	1	5	-.47
Low abdominal pain	2.54	1.16	1	5	.22
Impairment due to urgency	2.91	1.14	1	5	-.20
Impairment due to dysuria	2.61	1.30	1	5	.05
Impairment due to frequency	2.96	1.20	1	5	-.19
Impairment due to pain	2.40	1.15	1	5	.19
Day 1					
Urgency	2.50	1.00	1	5	.49
Dysuria	2.16	1.06	1	5	.87
Frequency	2.46	1.01	1	5	.26
Low abdominal pain	2.04	1.01	1	5	.55
Impairment due to urgency	2.21	1.06	1	5	.62
Impairment due to dysuria	1.99	1.04	1	5	.89
Impairment due to frequency	2.18	1.01	1	5	.55
Impairment due to pain	1.91	1.00	1	5	.84

*Response rate ranged between n = 118 to 119 on day 0 and was n = 112 on day 1

Table 2. Reliability of the UTI-SIQ

Items	Alpha	Corrected item total correlation
Day 0	.86	
Urgency		.71
Dysuria		.63
Frequency		.57
Low abdominal pain		.44
Impairment due to urgency		.76
Impairment due to dysuria		.67
Impairment due to frequency		.70
Impairment due to pain		.39
Day 1	.91	
Urgency		.77
Dysuria		.67
Frequency		.74
Low abdominal pain		.58
Impairment due to urgency		.83
Impairment due to dysuria		.74
Impairment due to frequency		.83
Impairment due to pain		.58

*Response rate ranged between n = 118 to 119 on day 0 and was n = 112 on day 1

Table 3. Factorial validity of the UTI-SIQ-8

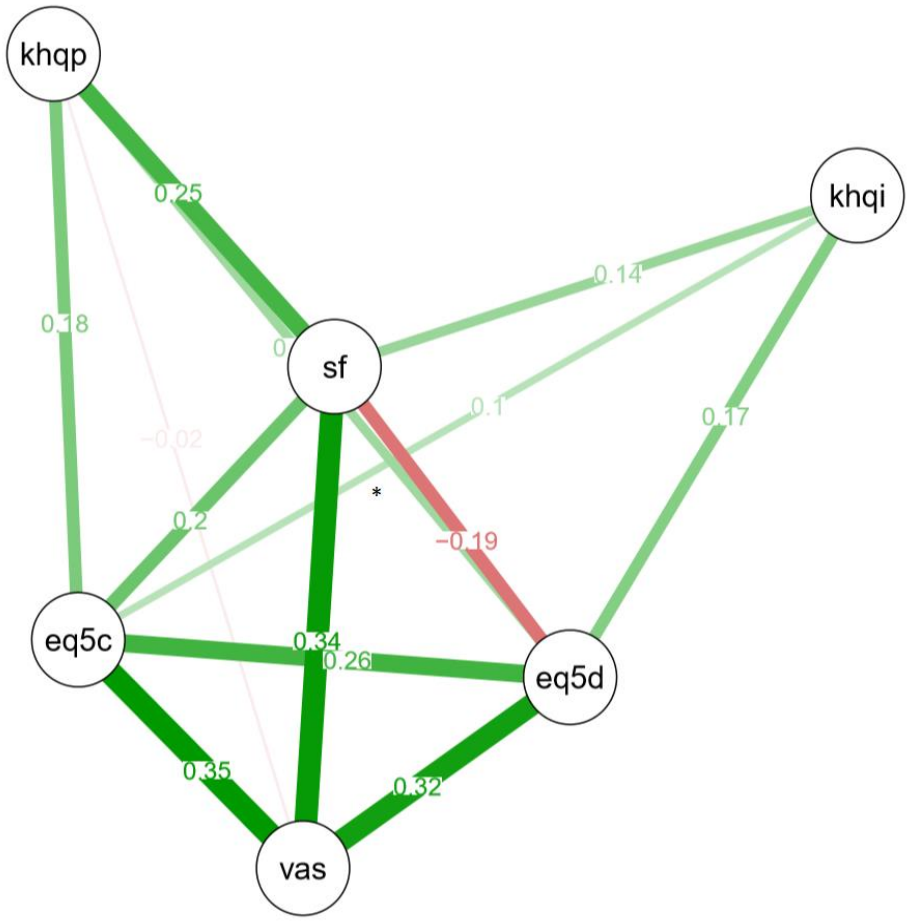
Items	Item loadings	
	Factor 1	Factor 2
Day 0*		
Urgency	0.87	-0.03
Dysuria	0.66	0.17
Frequency	0.88	-0.25
Low abdominal pain	-0.03	0.96
Impairment due to urgency	0.86	0.05
Impairment due to dysuria	0.67	0.22
Impairment due to frequency	0.88	-0.06
Impairment due to pain	-0.07	0.97
Day 1**		
Urgency	0.91	-0.06
Dysuria	0.76	0.00
Frequency	0.87	-0.04
Low abdominal pain	0.01	0.97
Impairment due to urgency	0.88	0.04
Impairment due to dysuria	0.84	-0.02
Impairment due to frequency	0.86	0.09
Impairment due to pain	0.01	0.97

* Variance explained: 74%

** Variance explained: 79%

Table 4. Convergent and divergent validity of the UTI-SIQ-8

Other instruments	Pearson's r (p)
Convergent validity	
Pain and usual activities (EQ-5D)	.51 (<0.001)
VAS pain	.54 (< 0.001)
Divergent validity	
Incontinence (KHQ_G)	.28 (0.002)
Mobility, self-care, anxiety/depression (EQ-5D)	.23 (0.12)



* Green lines indicate a positive connection; red lines indicate a negative connection. The saturation of the lines indicates the strength of a connection.

Sf = UTI Symptom and Impairment Questionnaire (UTI-SIQ-8)
VAS = Visual Analog Scale for rating pain
eg5c = EQ-5D; pooled items usual activities, pain/discomfort
eg5d = EQ-5D; pooled items reduced mobility, self-care, and anxiety/depression
khqi = King's Health Questionnaire; scale "incontinence"
khqp = King's Health Questionnaire; scale "personal relations"

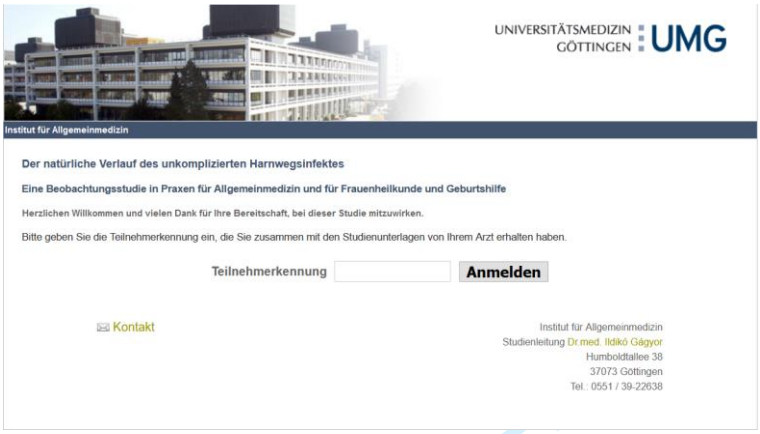
Figure 1. Network analysis

Appendix 1

Examples of the electronic version of the UTI-SIQ-8 (via tablet or smartphone)

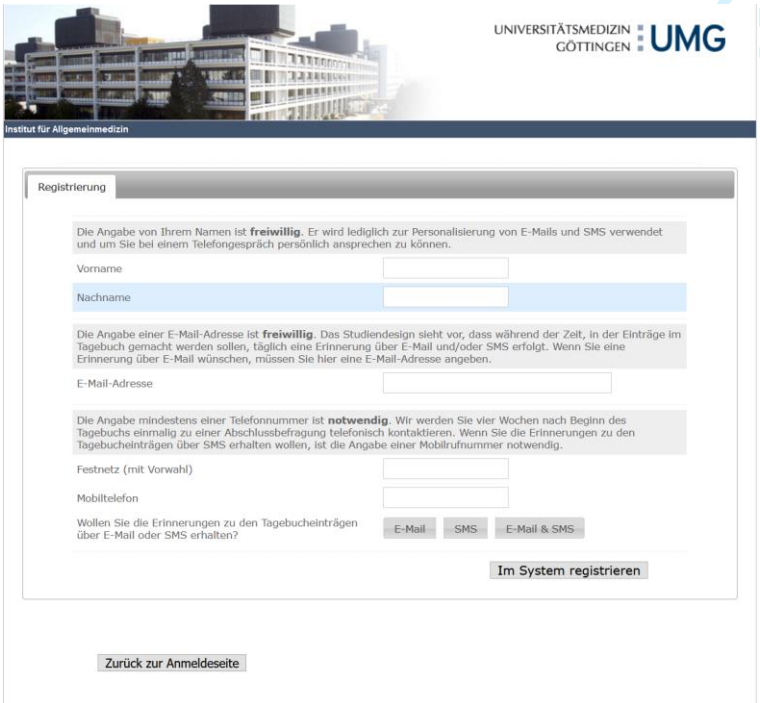
Start screen

Participants have to sign up with an individual registration code.



Registry

Users can provide personal information on a voluntary basis for a telephone conversation and a daily reminder.

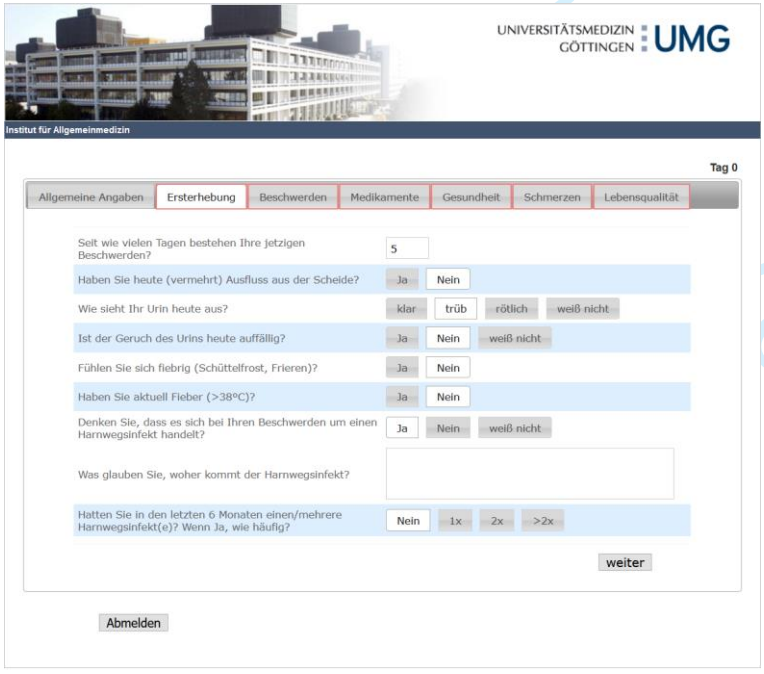


Welcome

Participants are welcomed and informed about the time schedule of the study. Data protection is emphasized.

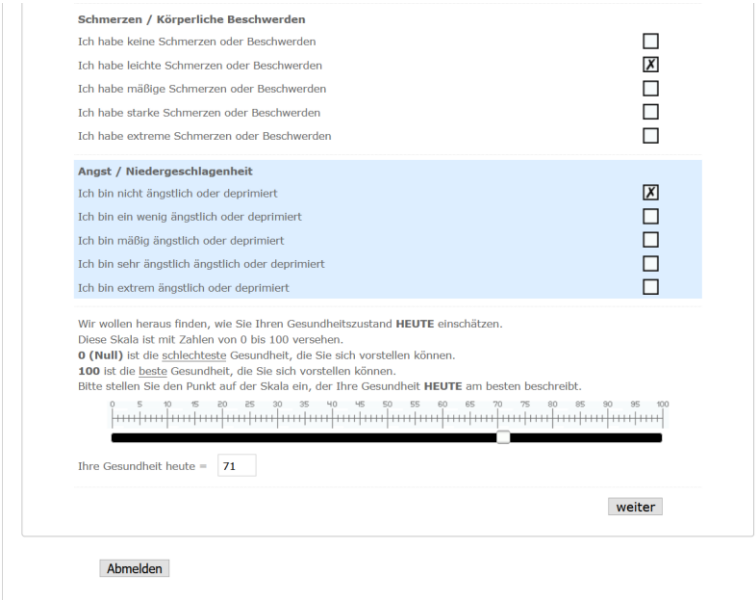
Initial assessment

Participants are asked for an initial assessment regarding symptom duration, urine quality, fever, etc.



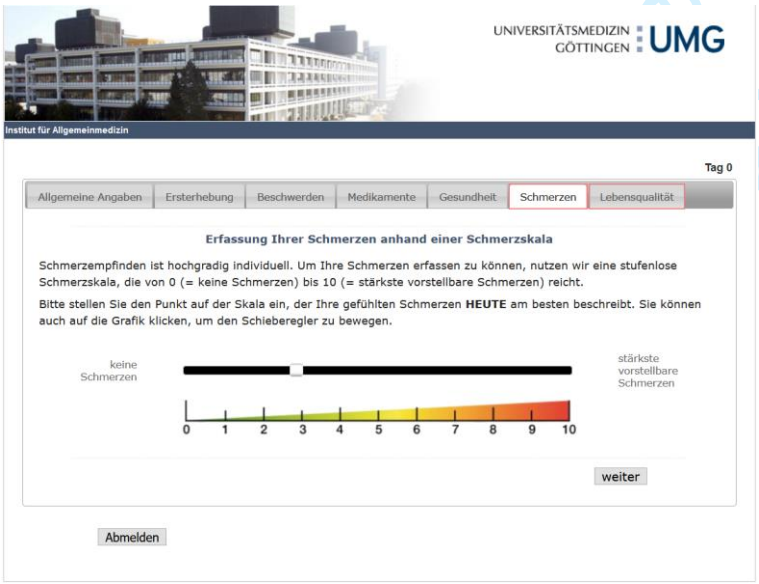
EQ-5D-5L (excerpt)

Participants evaluate their current state of health (only for the validation study)



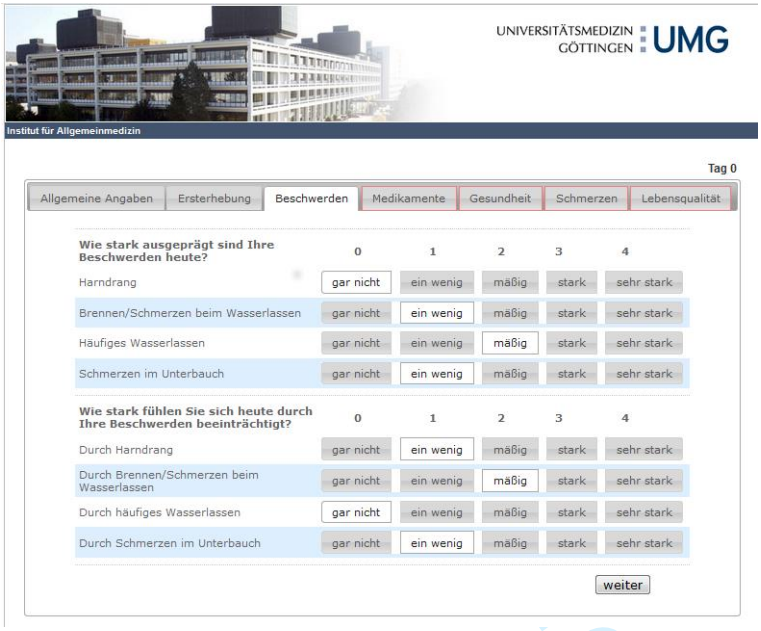
Visual analog scale

Participants assess pain intensity on a scale of 0 to 10 (only for the validation study)



UTI-SIQ-8

Participants evaluate severity of symptoms and impairment



Appendix 2

The UTI-SIQ-8 (in German and English translation)

Pat. Code

Patientenfragebogen (lang)

Bei den folgenden 8 Fragen geht es darum, wie stark Ihre Beschwerden **h e u t e** sind bzw. wie stark Sie sich **h e u t e** durch Ihre Beschwerden beeinträchtigt fühlen.

Bitte kreuzen Sie pro Zeile **e i n** Kästchen an

Wie stark sind Ihre Beschwerden heute?	gar nicht	ein wenig	mäßig	stark	sehr stark
	0	1	2	3	4
1. Harndrang	☐	☐	☐	☐	☐
2. Schmerzen beim Wasserlassen	☐	☐	☐	☐	☐
3. Häufiges Wasserlassen	☐	☐	☐	☐	☐
4. Schmerzen im Unterbauch	☐	☐	☐	☐	☐

Wie stark fühlen Sie sich heute durch Ihre Beschwerden beeinträchtigt?	gar nicht	ein wenig	mäßig	stark	sehr stark
	0	1	2	3	4
5. Beeinträchtigung durch den Harndrang	☐	☐	☐	☐	☐
6. Beeinträchtigung durch Schmerzen beim Wasserlassen	☐	☐	☐	☐	☐
7. Beeinträchtigung durch häufiges Wasserlassen	☐	☐	☐	☐	☐
8. Beeinträchtigung durch Schmerzen im Unterbauch	☐	☐	☐	☐	☐

Pat. Code

6

Patient questionnaire (long)

Please indicate whether you have had the following symptoms/problems today and how severe they were today.

Please check only one box per line.

How severe are your symptoms today?	not at all	Mild	moderate	strong	very strong
	0	1	2	3	4
1. Urgency of urination	☐	☐	☐	☐	☐
2. Pain or burning when passing urine	☐	☐	☐	☐	☐
3. Frequency of urination	☐	☐	☐	☐	☐
4. Pain in the lower abdomen	☐	☐	☐	☐	☐

How much impairing are the symptoms for you today?	not at all	Little	moderate	severe	very severe
	0	1	2	3	4
5. Impaired activities due to urgency	☐	☐	☐	☐	☐
6. Impaired activities due to pain while passing urine	☐	☐	☐	☐	☐
7. Impaired activities due to frequency of urination	☐	☐	☐	☐	☐
8. Impaired activities due to pain in the lower abdomen	☐	☐	☐	☐	☐

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Psychometric properties of a self-assessment questionnaire concerning symptoms and impairment in urinary tract infections: the UTI-SIQ-8

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Psychometric properties of a self-assessment questionnaire concerning symptoms and impairment in urinary tract infections: the UTI-SIQ-8

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Abstract

Objectives To validate the UTI Symptom and Impairment Questionnaire (UTI-SIQ-8), a questionnaire that consists of 4 items to assess the symptom severity for dysuria, urgency, frequency, and low abdominal pain, and 4 items to assess the resulting impairment of activity by urinary tract infections (UTI).

Design Prospective observation study.

Setting German primary care practices.

Participants An unselected population of women with UTI. Women could participate online via a Web application for smartphones, smartwatches, and tablets or use a paper-and-pencil version.

Main outcomes Psychometric properties of the UTI-SIQ-8 regarding reliability, validity, and sensitivity to change by utilizing factor analysis, and multilevel and network analysis.

Results Data from 120 women with a total of 769 symptom reports across seven days of measurement were analysed. The majority of the participating patients (87/120) used the Web application via smartphones or other devices. The reliability of the UTI-SIQ-8 was high, with Cronbach's alpha of .89 at intake; convergent and discriminant validity was satisfactory. Intraclass correlation demonstrated high sensitivity to change, with 68 per cent of the total variance being due to time differences. These daily changes in an individual's symptoms moved parallel with daily changes in the EQ-5D-5L ($b = 1.68$, $SE = 0.12$, $p < .001$) and the VAS ($b = 0.03$, $SE = 0.003$, $p < .001$), also highlighting convergent validity with respect to daily changes in symptom severity.

Conclusions The present findings support the UTI-SIQ-8 questionnaire as an economic, reliable, and valid instrument for the assessment of symptom severity and symptom change in women with uncomplicated UTI. The Web application helped patients to report symptoms on a daily basis. These findings may encourage primary care physicians to use the UTI-SIQ-8 in their daily practice and researchers to apply it to studies involving patients with uncomplicated UTI.

Word count: 294

Keywords: Urinary Tract Infection, Psychometrics, Surveys and Questionnaires, Quality of Life, Symptom Assessment, Primary Health Care

Strengths and limitations of this study

► As we followed patients in their daily life on a day to day basis, our study is highly ecologically valid which makes the UTI-SIQ-8 relevant for primary care physicians to use it in their daily practice and researchers to apply it to studies involving patients with uncomplicated UTI.

► The diary-design of this study and the use of a Web app allowed us to collect more than 750 data entries throughout the study highlighting the statistical power of our analyses.

► Using network analyses is novel in UTI research and may give direction to future research for validating self-report questionnaires.

► The UTI-SIQ-8 questionnaire is deliberately kept short to ensure a feasible implementation in daily use.

► At present, we do not advise users to utilize the UTI-SIQ-8 for individual assessment because norm values or reference values are not yet available.

BACKGROUND

Urinary tract infections (UTIs) are common in primary care and encompass a considerable burden of symptoms for affected patients (1, 2). UTI occurs in women more often than men and the typical signs are urgency, frequency and dysuria, often accompanied by low abdominal or back pain, smelly urine, haematuria and pyuria (3, 4). From the women's perspective, particularly concerning symptom severity, the impairment and the impact on daily activities are of high relevance (4, 5).

While the initial symptoms of a UTI are essential for a diagnosis, the course of symptoms, especially in the first few days, is essential to evaluate the clinical effectiveness of treatment. Accordingly, randomised controlled trials (RCTs) in this discipline use questionnaires to inform about the severity of the symptoms at onset and along the course of a UTI (6–10). For example, Ferry et al. (11) used frequency, urgency, dysuria and supra-pubic pain as the most important patient-reported outcomes to assess success in their therapy study.

There are a couple of symptom questionnaires or diaries for UTI in use (12–17), most of them in English, but some were translated and validated in other languages, such as Norwegian (6), Chinese (18) or German (7, 19). Most questionnaires were developed for and validated in RCTs. However, transferability in usual care may be limited due to a selection process in RCTs. Some of the symptom questionnaires focused on the severity of UTI symptoms only (6, 8, 11), while others considered the impact of UTI on everyday activities (13). Some validation studies were concerned with both aspects (12, 20), and a Danish validation study of a condition-specific diary suggested to distinguish between severity, bothersomeness and impact on daily activities (17). But only a handful assessed a questionnaire's sensitivity to change apart from a proper diagnosis (19, 21). With a proper assessment of symptoms, as well as responsiveness or sensitivity to change, the Urinary Tract Infection Symptom Assessment (UTISA) (12) and the Current Acute Cystitis Symptom Score Questionnaire (ACSS) (20) appeared to be well-suited for primary care patients. The authors of both expected the participating women to fill in a rather large questionnaire, comprising 14 or 18-items.

The UTISA had to be completed at baseline and then at 3-h and 8-h intervals until all UTI symptoms were resolved.

In clinical settings, however, there is a clear need to lower the response burden on patients, especially to when the course of the disease should be followed up daily. Moreover, modern surveillance technologies increase the applicability of questionnaires (22). Following the symptoms as suggested by Ferry et al. (11) and other researchers, we developed a short questionnaire comprising dysuria, frequency, urgency and suprapubic pain, with the possibility for women to assess both severity of UTI symptoms and impairment by these symptoms (bothersomeness), as suggested, among others, by Clayson et al. (12). We have used this new questionnaire in two RCTs (23, 5); however, it has not been validated in the targeted population yet.

Hence, the present study aimed to validate this short self-report questionnaire to measure symptom severity and impairment by urinary tract infections and its course—called the UTI Symptom and Impairment Questionnaire, UTI-SIQ-8—in an unselected population of women with UTI in German primary care. An additional objective was to prove the applicability of a Web application among participating women.

METHODS

The study was performed from November 2016 to May 2018 and comprised the following steps: (1) questionnaire development, (2) compilation of additional questionnaires and measuring tools for validation purposes, (3) sample size calculation, (4) recruitment of participants, (5) data collection, and (6) statistical analyses.

Development of the UTI-SIQ-8 Questionnaire

The development process involved in its early stage a multiprofessional team of general practitioners, young doctors, psychiatrists, social scientists, and study nurses. First, we chose outcome criteria used by Ferry et al. (11) in their therapy study and by Clayson et al. (12) in their validation study and which women reported in the survey of Colgan et al. (24), i.e., frequent urination, urgency in urination, pain during urination (dysuria) and pain/pressure in lower stomach (abdominal pain). Following Clayson et al. (12), we found it important to ask women for severity and impairment by these symptoms in daily life (bothersomeness). Then the multiprofessional team discussed the wording, order of the questions and the answer scores to come to relevant and clear items for women suffering from UTI. We used this version in two RCTs (5, 23) where the questionnaire proved to be feasible.

The final UTI-SIQ-8 questionnaire consists of 4 items to assess the symptom severity for dysuria, urgency, frequency and low abdominal pain. These items were scored from 1 (no symptoms at all) to 5 (very strong symptoms); 4 items assess the impact of these symptoms (bothersomeness), scored from 1 (no impairment at all) to 5 (very strong impairment). The questionnaire (and an English translation) can be seen in Appendix 1.

Compilation of questionnaires and tools for validation purposes

To validate the UTI-SIQ-8 questionnaire, we chose the following questionnaires and tools:

King's Health Questionnaire, German version (KHQ_G). The KHQ is a self-administered questionnaire designed to assess the impact of urinary incontinence on quality of life. The measure

was originally designed for use in women and contains 32 questions, which are scored in 10 domains. Weighted summary scores in each domain range from 0 to 100, with higher scores indicating greater impairment. The KHQ has been validated for use in assessing women with urinary problems, such as an overactive bladder (25, 23). A German version (KHQ_G) has also been validated (16).

EQ-5D-5L. We used a validated German version of the EQ-5D-5L (hereafter abbreviated as EQ-5D), which evaluates the generic quality of life and comprises five dimensions (= 5D), each describing a different aspect of a patient's health status : mobility, self-care, usual activities, pain/discomfort and anxiety/depression, with a 5-level (= 5 L) answer format (26).

Visual analogue scale for pain. We used a simple numeric-geometric scale (VAS) to assess pain. It was developed and validated for use in clinical practice (27).

Sample size calculation

One main criterion for the validation of our questionnaire was its sensitivity to change. We first calculated a sample size of more than 200 patients to have enough statistical power for latent variable models to detect change. Since it proved difficult to reach such a sample size in busy primary care practices, we made use of multilevel models on basis of a high number of data entries and manifest variables that ensured the statistical power of our analysis to detect change.

Participants

We invited 298 primary care physicians (i.e., general practitioners and community gynaecologists) in Germany to achieve a sample of approximately 20 practices. Community gynaecologists are besides general practitioners the most often consulted physicians for UTI in German primary care (28). All participating physicians provided written informed consent.

Participating patients were included using convenient sampling. This method seemed to be practically applicable in daily routine. Patients were selected by the responsible medical assistants and physicians according to the defined inclusion and exclusion criteria. Women, 18 years and older, with a suspected

uncomplicated UTI (with dysuria, urgency, frequency and low abdominal pain), were invited to participate. Women with signs of a complicated infection were not included. Participants, who gave informed consent received an electronic code that allowed them to access a daily electronic questionnaire for the following 7 days. For more details, refer to (29).

Screening lists were used to calculate the participation rate. However, these lists proved not to be reliable because, due to the time pressure in day-to-day business, practice nurses had, due to practice stress, difficulties to fill in them adequately.

Data collection

All participating women completed a baseline data sheet in the practice with demographic details, such as age, partnership, children and professional qualifications, and a medical history including appearance and smell of urine, accompanying symptoms such as fever and duration of symptoms. Urine samples were tested for leukocytes, erythrocytes and nitrite in the practice and sent to the laboratory in charge to be tested for the type of germ, number, and resistance profile.

Each woman was asked to complete the UTI-SIQ-8 questionnaire at inclusion and for 7 days consecutively. Besides, women completed the King's Health Questionnaire (KHQ_G) for assessing the quality of life in women with urinary incontinence, the EQ-5D, to measure the health-related quality of life and a visual analogue scale (VAS) for rating pain. The questionnaires in the study were used for self-assessment either at inclusion only (KHQ_G) or also for the following 7 days (UTI-SIQ-8, VAS pain scale, EQ-5D).

Women could enter their data online via a Web application for smartphones, smartwatches, and tablets, including a gentle daily reminder to fill in the questionnaires. Online data collection was realised by a specifically programmed, responsive, dynamic web form. Data transmission was always ensured to be encrypted via SSL/HTTPS. All personal data stored in the relational MySQL database was encoded via symmetric salted cryptography algorithms. All survey data was stored in separate data tables and allocated using only an anonymized participant-id. Moreover, regarding data export,

the participant-id was additionally scrambled, rendering the matching of survey data to personal information practically impossible (see Appendix 2). It was also possible to use a paper-and-pencil version to ensure participation of those who were not able to use the mobile app.

While the electronically collected data could be transferred directly into the database, the non-electronic data (paper-and-pencil version, urine test results) had to be entered by the study team manually.

Statistical analysis

The UTI-SIQ-8 was evaluated in 7 steps:

Item analysis. Mean scores, standard deviations (SDs), and ranges were analysed to evaluate item- and scale score distributions, especially to check for floor and ceiling effects.

Reliability. We determined Cronbach's alpha as a measure of internal consistency based on the intercorrelations among the test items.

Convergent validity. Convergent validity was assessed in terms of the strength of the associations between the UTI-SIQ-8 scores and the EQ-5D pain and activity scores and the VAS.

Discriminant validity. Discriminant validity was investigated by comparing UTI-SIQ-8 items and those EQ-5D and KHQ items that should measure distinct dimensions. For example, we expected that the KHQ incontinence item was only moderately correlated with the UTI-SIQ-8 total score.

Factorial validity. To explore the factorial structure and to check potential cross-loadings of the items, we ran a principal component analysis using Promax rotation, as we expected the influence of correlated factors. We used the scree-plot, the Kaiser criterion, and parallel analysis (30) as criteria to decide how many factors to extract. However, because the scree-plot criterion is somewhat subjective, and using the Kaiser criterion can render us susceptible to overestimating the number of factors, we used O'Connor' syntax (31) and ran a parallel analysis (30) to determine objective and reliable indices for factor extraction. To test for unidimensionality, we additionally ran a confirmatory

factor analysis using the R package lavaan (32). The model was estimated using maximum likelihood estimation. Model fit was assessed with the Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR) such that values of the CFI ≥ .90, RMSEA ≤ .08, and SRMR ≤ .11 are considered to reflect an acceptable fit to the data.

Sensitivity to change. To investigate sensitivity to change, we analysed whether changes across days in the UTI-SIQ-8 scores were associated with changes in quality of life (EQ-5D) and pain (VAS). To account for the hierarchical data structure, we used multilevel random coefficient modelling (33) with the R-package lme4 (34). Days (level 1) were nested within individuals (level 2). Two separate models were run to examine the co-variability between the quality of life (pain) and symptom severity measured via UTI-SIQ-8. To improve the interpretability of the model results, the predictor variables were group-mean centered before running the models. We also determined the intraclass correlation (ICC) as an indicator of the sensitivity to change of the UTI-SIQ-8. This process was mandated to determine the degree of changes expected in the UTI-SIQ-8 scores, which could be attributed to differences across days versus differences among people.

Network analysis. To determine the relative position of UTI-SIQ-8 among other theoretically relevant constructs of symptom severity and to further establish convergent and discriminant validity, we examined distinctive associations between the total score of the UTI-SIQ-8 and the measures of quality of life regarding autonomy and pain (both EQ-5D), pain (VAS), and impairment due to incontinence and impairment of personal relationships (both KHQ-G) by using network analysis. The novel approach of network analysis facilitates visualization, description, and significance testing of relations between variables while controlling for the influence of other variables. In network analysis, variables are called *nodes* and relations between variables are called *edges*. In the present analyses, we entered the UTI-SIQ-8 scale score, quality of life regarding autonomy and pain, pain (VAS), and impairment due to incontinence and impairment of personal relationships as the observed *nodes* of the network. *Edges* may be described as partial correlations controlling for all other relationships in the network (r_p). Network analyses were conducted using the R packages qgraph (35) and bootnet

(34). The analyses followed suggestions from Epskamp and colleagues (36). To address potential difficulties of interpretation, we followed the conservative way of regularization and interpretation.

Patient and public involvement

Patients and public were not involved in the planning and design of this study. All participants who were included in the study gave written informed consent after a thorough explanation of the procedures involved.

Ethics approval was obtained from the ethics committee of Göttingen Medical School (17/4/16).

RESULTS

Patient characteristics

A total of 18 practices with a total of 131 women took part in the study. We excluded 11 women from analysis due to screening failure or technical reasons, such as missing or erroneous data, resulting in a valid sample of 120 women with a total of 769 symptom reports across 7 days of measurement. The mean age of the women was 43.3 ± 16.6 years, the urine dipstick was positive for leucocytes in 92%, erythrocytes in 87%, and nitrites in 23% and the urine culture was positive in 82% (96/118). Escherichia coli was found in 78% (74/96) of the positive urine cultures. Detailed information on the patient characteristics is reported in (29).

The majority of the participating women (87/120) used the Web application via smartphone, smartwatches or tablets. In the patients 65 years and older, 12 women participated. Half of them (6/12) chose the electronic version.

Item analysis

Table 1 shows the mean scores and SDs, as well as further statistical characteristics of the 8 items of the UTI-SIQ-8 for the first 2 days, as reported by the women. They made use of the full scale (1 to 5) for all items on both days (Table 1), resulting in high SDs (1.0 to 1.79). The coefficients for skewness ranged from .048 to .466 on day 0, indicating a low level of skewness, and were somewhat higher on day 1. The mean scores strongly decreased from day 0 to day 1, indicating a sharp decline in symptom severity and impairment caused by these symptoms (bothersomeness). The distribution of the items on the following days was more positively skewed as most patients substantially recovered within a few days.

Insert Table 1 here

Reliability

Cronbach's alpha for the 8 items was high on day 0 (.86) and even higher on day 1 (.91), confirming the internal consistency of the UTI-SIQ-8. Notably, 6 items contributed equally to the reliability of the

scale and only 2 (abdominal) pain items did not correlate as high as the other items with the total score (Table 2).

Insert Table 2 here

Validity

Factorial validity. Preliminary results revealed one or three factors based on the conventional scree-plot criterion and three factors based on the Kaiser criterion. A parallel analysis, which provides more objective and reliable indices for factor extraction, highlighted two factors (Table 3). The two-factor solution explained 74% of total item variance and confirmed the special role of the two pain items as already detected by the corrected item-total correlations for the reliability analysis. While 6 of the items, referring to urgency, dysuria, and frequency, loaded high on one factor, both pain items loaded on a second factor. However, since Cronbach's alpha was satisfactory for all 8 items and all factors should consist of more than 2 items, we decided to use a one-factor solution as suggested by the scree-plot criterion for the following analyses.

Insert Table 3 here

To test for unidimensionality, a confirmatory factor analysis supported the one-factor solution (CFI = .922, RMSEA = .16, SRMR = .066) with correlated residuals between the items severity of dysuria and impairment (bothersomeness) due to dysuria and the items severity of low abdominal pain and impairment (bothersomeness) due to low abdominal pain. The model fit according to CFI and SRMR was acceptable and, although the RMSEA was somewhat above the cut-off value of .08.

Convergent validity. The UTI-SIQ-8 was significantly and positively correlated with the pain and activity subscales of the EQ-5D and the VAS (Table 4), confirming convergent validity. As expected, patients who reported stronger symptom severity and perceived impairment by UTI symptoms also reported more pain and an impairment of usual activities.

Insert Table 4 here

Discriminant validity. The correlations between the UTI-SIQ-8 and impairment due to incontinence as well as the activity subscale of the EQ-5D were smaller than the convergent validity correlations, exemplifying discriminant validity (Table 4). As expected, our results indicated that women who reported more severe symptoms and impairment by UTI symptoms, reported to a lesser degree that they suffered from incontinence but suffered more from pain and/or an impairment in usual activities. The correlation between reported symptom severity/impairment by UTI symptoms and impairment due to reduced mobility, self-care, or anxiety/depression was also lower than the correlation with pain or an impairment in usual activities. Both results highlight discriminant validity.

Sensitivity to change

The intraclass correlation (ICC = .32) indicates that 32 per cent of the total variance in the UTI-SIQ-8 scores were due to differences between the women and 68 per cent due to time differences. Differences between the item scores can be explained from daily changes in a person's symptoms, which highlights the sensitivity to change of the UTI-SIQ-8. Importantly, these daily changes in an individual's symptoms moved parallel with daily changes in the EQ-5D ($b = 1.68$, $SE = 0.12$, $p < .001$) and the VAS ($b = 0.03$, $SE = 0.003$, $p < .001$), thus highlighting convergent validity with respect to daily changes in symptom severity.

Network analysis

Figure 1 visualizes the estimated network of the UTI-SIQ-8. The UTI-SIQ-8 takes a central position between the VAS and some of the selected subscales of the EQ-5D and KHQ-G. Symptom severity, as assessed with the UTI-SIQ-8, exhibited a unique connection with pain as assessed with the VAS ($r_p = .34$) and, to a smaller extent, with impairment in personal relationships (KHQ-G; $r_p = .25$) and usual activities and pain/discomfort (EQ-5D; $r_p = .20$). Symptom severity (UTI-SIQ-8) was only slightly related to impairment due to incontinence (KHQ-G, $r_p = .14$) and negatively related to mobility, self-care, and anxiety/depression (EQ-5D; $r_p = -.19$).

Insert Figure 1 here

DISCUSSION

The UTI-SIQ-8 proved to be a reliable and valid questionnaire to measure symptom severity and impairment (bothersomeness) and the symptom course in women with UTI in German primary care. Women made use of the full scale of the 8 items to assess the severity of their symptoms and the resulting impairment. Reliability was high, with a Cronbach's alpha of around 0.9; convergent and divergent validity were also satisfactory. The daily changes in a woman's assessment of her symptoms moved parallel to the EQ-5D scores and the VAS for pain, underlining the convergent validity of the questionnaire for sensitivity to change. Network analysis showed a central position of the UTI-SIQ-8 between other measures of pain and the quality of life questionnaires (KHQ_G and EQ-5D). The Web application was the women's preferred form to complete the questionnaire online.

Strengths and limitations

This is a validation study of a short UTI questionnaire that comprised both symptom severity and resulting impairment as perceived by women at consultation and during the course of symptoms. The validation study was conducted separately from the REGATTA trial (5, 23) to mitigate the risk of a selection bias, which is more likely in an RCT. We used different validation methods to demonstrate all relevant forms of validity and to inform future users about applicability.

Participating women had to complete a myriad of questionnaires but the UTI-SIQ-8 questionnaire is deliberately kept short to ensure a feasible implementation in daily use. There is some discussion about whether or not a shorter questionnaire lowers response burden and improves response rate. Rolstad et al. (37) concluded in their review on response burden that there is a greater chance of response when patients were presented with a short questionnaire. They also argue that the quality of the content matters more from the patient's point of view than the length *per se*. However, since more items than absolutely necessary, daily or even more frequently asked, as other researches did, may be a stress at least for some women, we consider the 8-item-survey an advantage of our study.

Our study was highly ecologically valid, as we followed patients in their daily life on a day to day basis. Because of the diary-design of this study and the use of an online app, we were able to collect more than 750 data entries throughout the study highlighting the statistical power of our analyses. Using network analyses (35) is novel in UTI research and may give direction to future research. For example, our research provided evidence that symptom severity, as assessed with the UTI-SIQ-8, takes a central position between the VAS and some of the selected subscales of the EQ-5D and KHQ-G supporting construct validity of our instrument.

Although the design of the study required only a small sample size of participating patients, the data suggest that the study population was comparable to other UTI studies in Germany. For example, a positive urine culture (approx. 75%), prevalent among women with E. coli infections, and the susceptibility data were analogous with the results of other observational studies in Germany and RCTs (5–7, 25, 38, 39).

At present, we do not advise users to utilize the UTI-SIQ-8 for individual assessment because norm values or reference values are not yet available. Still, the questionnaire revealed satisfactory to good psychometric properties and it can thus be strongly recommended to use the UTI-SIQ-8 in research.

Comparison with existing literature

Similar to the UTISA questionnaire (12), the UTI-SIQ-8 allowed women to rate the different UTI-related symptoms according to their severity and impairment (bothersomeness). In line with this study, we found that the severity and bothersomeness items loaded on the same factor. In other words, if a woman perceived a UTI-symptom as severe, it also strongly affected her perceived impairment and vice versa. However, the authors of the UTISA decided after analysis to determine 'urination regularity' and 'problems with urination' as two different factors, as they did for pain symptoms. Our analysis inspired us to merge these items and we feel that the one-factor solution is logical from the patient perspective and allows a rapid and simple assessment of UTI symptoms and change across days.

Another self-reporting questionnaire, the Acute Cystitis Symptom Score (ACSS) (20), translated in many languages, also proved to be highly reliable and sensitive to change. While the 18-items questionnaire aims to assess the symptom severity and quality of life, in the first and the follow-up consultation, the UTI-SIQ-8 aims to assess symptom severity and bothersomeness on a day by day basis. This feature allows sensible monitoring of the symptom course as shown by several studies (6–8). Furthermore, these studies used a symptom diary, which was developed for RCTs to assess the UTI symptom at inclusion and to follow-up the symptom course and duration. The diary was validated for acute lower respiratory tract infections and showed good reliability and sensitivity to change but not for UTI. While it was unclear whether the results of the validation study are transferable to UTI patients, our analysis confirms the validity of this diary-based symptom assessment.

The items for low abdominal pain did not correlate as high as the other items with the total score of the UTI-SIQ-8, signaling a special role compared to the other symptoms. This finding corresponds to the results of Holm's et al. (17) validation study where the three items Pain on urination, Difficulties emptying the bladder and Uncomfortable pressure around the bladder belonged to one dimension while a Burning sensation on urination and Pain around the bladder belonged to another dimension so that the authors concluded: patients must have perceived these as fundamentally different symptoms. We would not go so far but, indeed, abdominal pain seems only moderately linked with the remaining symptoms, namely urgency, frequency and dysuria. Obviously not all women with UTI perceive abdominal pain, but nearly each woman with acute UTI experience urgency, frequency and dysuria (24, 11) . Since it is an important and troublesome symptom, as also Ferry et al. (11)suggested, we decided to leave the two pain items in the UTI-SIQ-8, but not as a factor of its own.

Implications for practice and further research

The UTI-SIQ-8 could be used for the baseline assessment of symptom severity in women with uncomplicated UTI and may help to decide whether or not to start with symptomatic treatment by using the delayed prescription approach (8). It can also be used to follow-up the course of the symptoms and their duration on a day by day basis to monitor treatment success and make changes in the treatment, if needed. A mobile health application could help to detect patients with worsening symptoms of complications, as demonstrated for other conditions (40). Further research is needed to identify the cut-off values for clinically relevant changes of the symptom course and duration.

As a side effect, the study indicates that Web applications can be used for data collection via smartphones or other devices in all age groups, also for older patients.

Conclusions

The present findings support the UTI-SIQ-8 questionnaire as an economic, reliable, and valid instrument for the assessment of symptom severity and symptom change in women with uncomplicated UTI. These findings may encourage primary care physicians to use it in their daily practice and researchers to apply it to studies involving patients with uncomplicated UTI.

Declarations

Ethical approval

The ethics committee of Göttingen Medical School approved the study (17/4/16). All participating physicians and patients provided written informed consent.

Consent for publication

Not applicable.

Availability of data and materials

The data used for the current study are available from the corresponding author on reasonable request.

Conflict of interest

The authors have nothing to disclose.

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Authors' contributions

IG had the initial study idea; all authors worked out the final design of the study. SSP collected the data. KR performed all statistical analyses. IG and WH were the major contributors in writing the manuscript and are the guarantors of the paper. All authors read, discussed, and approved the final manuscript.

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Table 1. Distribution of responses to each UTI-SIQ-8 item

	Day; m (SD)				
Item *	Mean	SD	Min	max	skewness
Day 0					
Urgency	3.37	1.07	1	5	-.45
Dysuria	2.75	1.34	1	5	.05
Frequency	3.35	1.09	1	5	-.47
Low abdominal pain	2.54	1.16	1	5	.22
Impairment due to urgency	2.91	1.14	1	5	-.20
Impairment due to dysuria	2.61	1.30	1	5	.05
Impairment due to frequency	2.96	1.20	1	5	-.19
Impairment due to pain	2.40	1.15	1	5	.19
Day 1					
Urgency	2.50	1.00	1	5	.49
Dysuria	2.16	1.06	1	5	.87
Frequency	2.46	1.01	1	5	.26
Low abdominal pain	2.04	1.01	1	5	.55
Impairment due to urgency	2.21	1.06	1	5	.62
Impairment due to dysuria	1.99	1.04	1	5	.89
Impairment due to frequency	2.18	1.01	1	5	.55
Impairment due to pain	1.91	1.00	1	5	.84

*Response rate ranged between n = 118 to 119 on day 0 and was n = 112 on day 1

Table 2. Reliability of the UTI-SIQ

Items	Alpha	Corrected item total correlation
Day 0	.86	
Urgency		.71
Dysuria		.63
Frequency		.57
Low abdominal pain		.44
Impairment due to urgency		.76
Impairment due to dysuria		.67
Impairment due to frequency		.70
Impairment due to pain		.39
Day 1	.91	
Urgency		.77
Dysuria		.67
Frequency		.74
Low abdominal pain		.58
Impairment due to urgency		.83
Impairment due to dysuria		.74
Impairment due to frequency		.83
Impairment due to pain		.58

*Response rate ranged between n = 118 to 119 on day 0 and was n = 112 on day 1

Table 3. Factorial validity of the UTI-SIQ-8

Items	Item loadings	
	Factor 1	Factor 2
Day 0*		
Urgency	0.87	-0.03
Dysuria	0.66	0.17
Frequency	0.88	-0.25
Low abdominal pain	-0.03	0.96
Impairment due to urgency	0.86	0.05
Impairment due to dysuria	0.67	0.22
Impairment due to frequency	0.88	-0.06
Impairment due to pain	-0.07	0.97
Day 1**		
Urgency	0.91	-0.06
Dysuria	0.76	0.00
Frequency	0.87	-0.04
Low abdominal pain	0.01	0.97
Impairment due to urgency	0.88	0.04
Impairment due to dysuria	0.84	-0.02
Impairment due to frequency	0.86	0.09
Impairment due to pain	0.01	0.97

* Variance explained: 74%

** Variance explained: 79%

Table 4. Convergent and divergent validity of the UTI-SIQ-8

Other instruments	Pearson's r (p)
Convergent validity	
Pain and usual activities (EQ-5D)	.51 (<0.001)
VAS pain	.54 (< 0.001)
Divergent validity	
Incontinence (KHQ_G)	.28 (0.002)
Mobility, self-care, anxiety/depression (EQ-5D)	.23 (0.12)

* Green lines indicate a positive connection; red lines indicate a negative connection. The saturation of the lines indicates the strength of a connection.

Sf = UTI Symptom and Impairment Questionnaire (UTI-SIQ-8)
VAS = Visual Analog Scale for rating pain
eg5c = EQ-5D; pooled items usual activities, pain/discomfort
eg5d = EQ-5D; pooled items reduced mobility, self-care, and anxiety/depression
khqi = King's Health Questionnaire; scale "incontinence"
khqp = King's Health Questionnaire; scale "personal relations"

Figure 1. Network analysis

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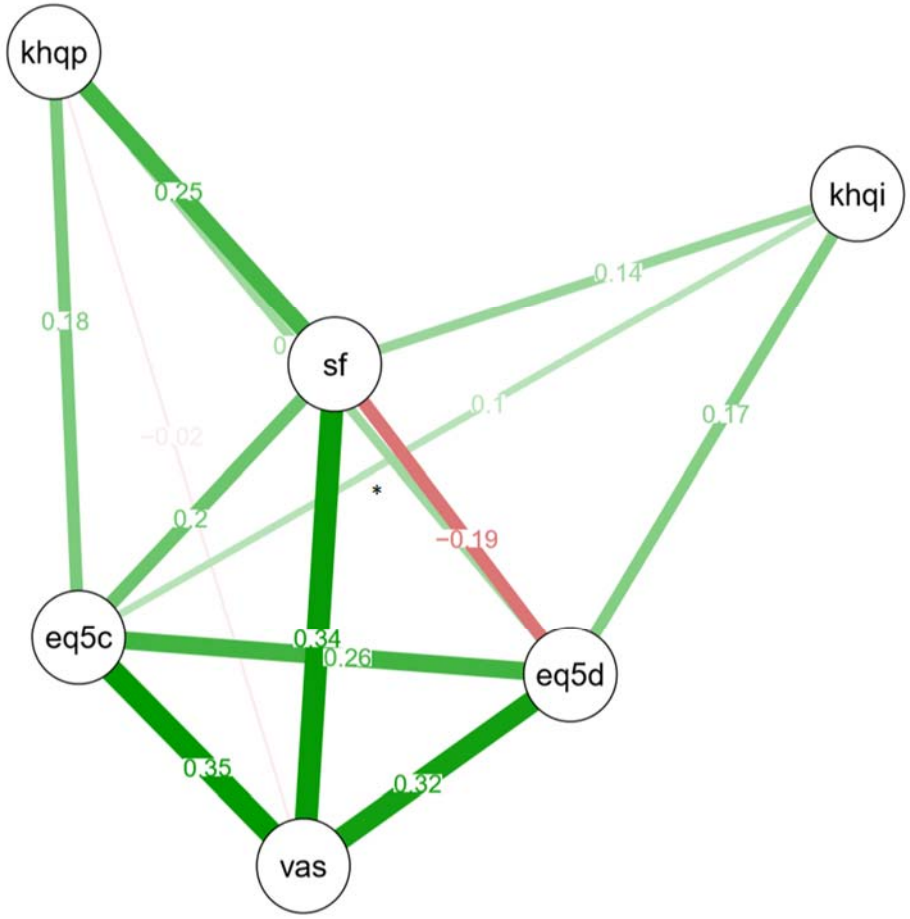


* Green lines indicate a positive connection; red lines indicate a negative connection. The saturation of the lines indicates the strength of a connection.

Sf = UTI Symptom and Impairment Questionnaire (UTI-SIQ-8)
VAS = Visual Analog Scale for rating pain
eg5c = EQ-5D; pooled items usual activities, pain/discomfort
eg5d = EQ-5D; pooled items reduced mobility, self-care, and anxiety/depression
khqi = King's Health Questionnaire; scale "incontinence"
khqp = King's Health Questionnaire; scale "personal relations"

Figure 1. Network analysis

Appendix 1

The UTI-SIQ-8 (in German and English translation)

Pat. Code

Patientenfragebogen

Bei den folgenden 8 Fragen geht es darum, wie stark Ihre Beschwerden **h e u t e** sind bzw. wie stark Sie sich **h e u t e** durch Ihre Beschwerden beeinträchtigt fühlen.

Bitte kreuzen Sie pro Zeile **e i n** Kästchen an

Wie stark sind Ihre Beschwerden heute?	gar nicht	ein wenig	mäßig	stark	sehr stark
	0	1	2	3	4
1. Harndrang	☐	☐	☐	☐	☐
2. Schmerzen beim Wasserlassen	☐	☐	☐	☐	☐
3. Häufiges Wasserlassen	☐	☐	☐	☐	☐
4. Schmerzen im Unterbauch	☐	☐	☐	☐	☐

Wie stark fühlen Sie sich heute durch Ihre Beschwerden beeinträchtigt?	gar nicht	ein wenig	mäßig	stark	sehr stark
	0	1	2	3	4
5. Beeinträchtigung durch den Harndrang	☐	☐	☐	☐	☐
6. Beeinträchtigung durch Schmerzen beim Wasserlassen	☐	☐	☐	☐	☐
7. Beeinträchtigung durch häufiges Wasserlassen	☐	☐	☐	☐	☐
8. Beeinträchtigung durch Schmerzen im Unterbauch	☐	☐	☐	☐	☐

Pat. Code

Patient questionnaire

Please indicate whether you have had the following symptoms/problems today and how severe they were today.

Please check only one box per line.

How severe are your symptoms today?	not at all	Mild	moderate	strong	very strong
	0	1	2	3	4
1. Urgency of urination	☐	☐	☐	☐	☐
2. Pain or burning when passing urine	☐	☐	☐	☐	☐
3. Frequency of urination	☐	☐	☐	☐	☐
4. Pain in the lower abdomen	☐	☐	☐	☐	☐

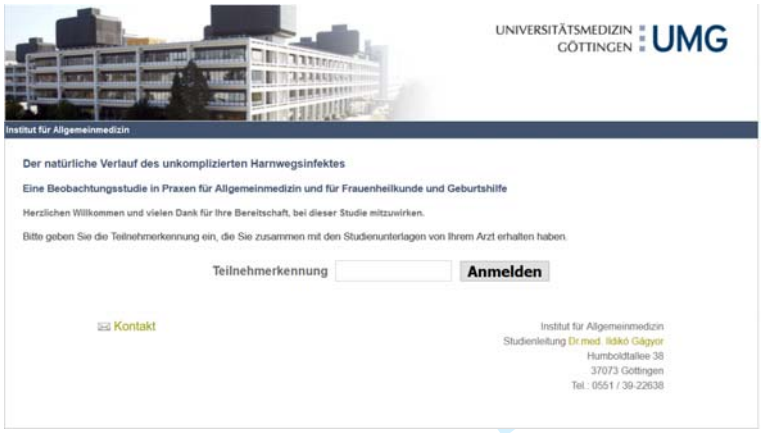
How much impairing are the symptoms for you today?	not at all	Little	moderate	severe	very severe
	0	1	2	3	4
5. Impaired activities due to urgency	☐	☐	☐	☐	☐
6. Impaired activities due to pain while passing urine	☐	☐	☐	☐	☐
7. Impaired activities due to frequency of urination	☐	☐	☐	☐	☐
8. Impaired activities due to pain in the lower abdomen	☐	☐	☐	☐	☐

Appendix 2

Examples of the electronic version of the UTI-SIQ-8 (via tablet or smartphone)

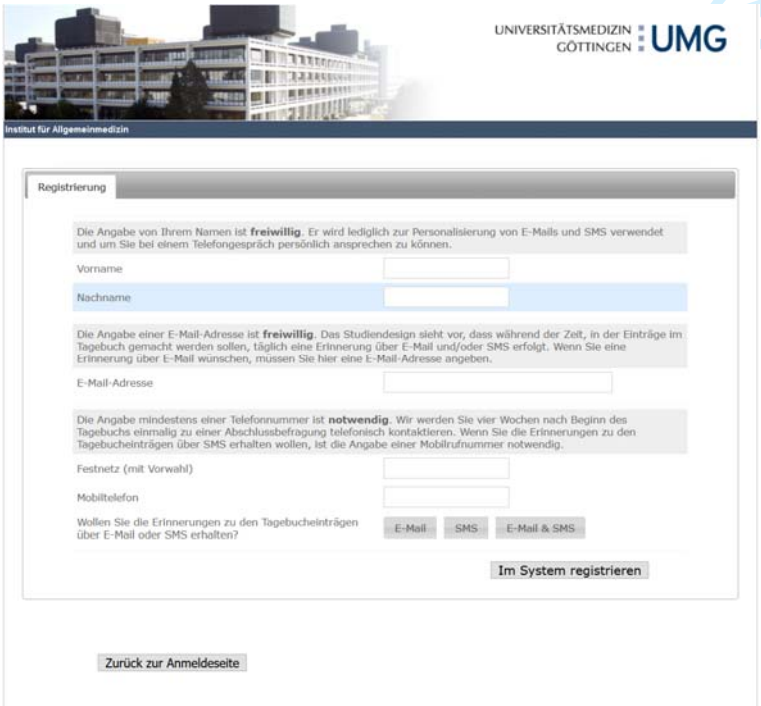
Start screen

Participants have to sign up with an individual registration code.



Registry

Users can provide personal information on a voluntary basis for a telephone conversation and a daily reminder.

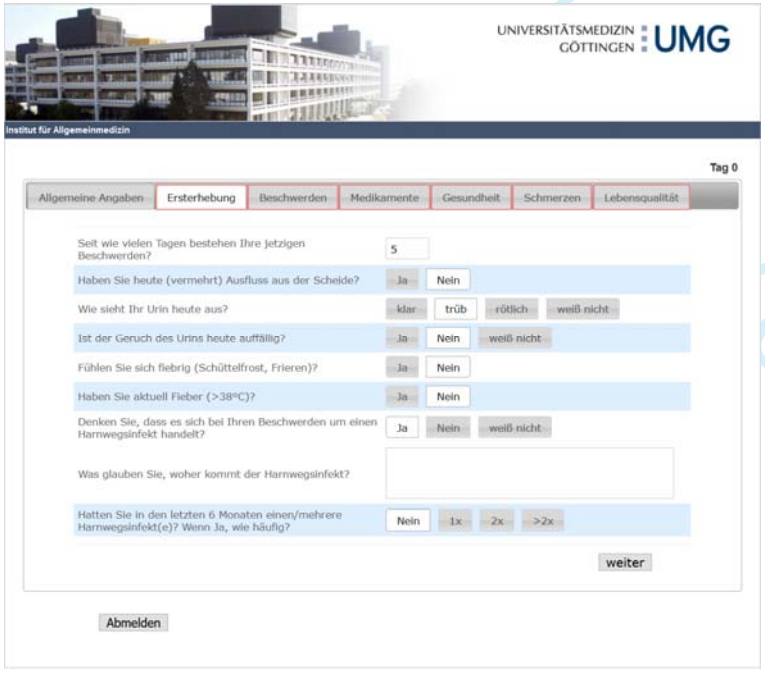


Welcome

Participants are welcomed and informed about the time schedule of the study. Data protection is emphasized.

Initial assessment

Participants are asked for an initial assessment regarding symptom duration, urine quality, fever, etc.

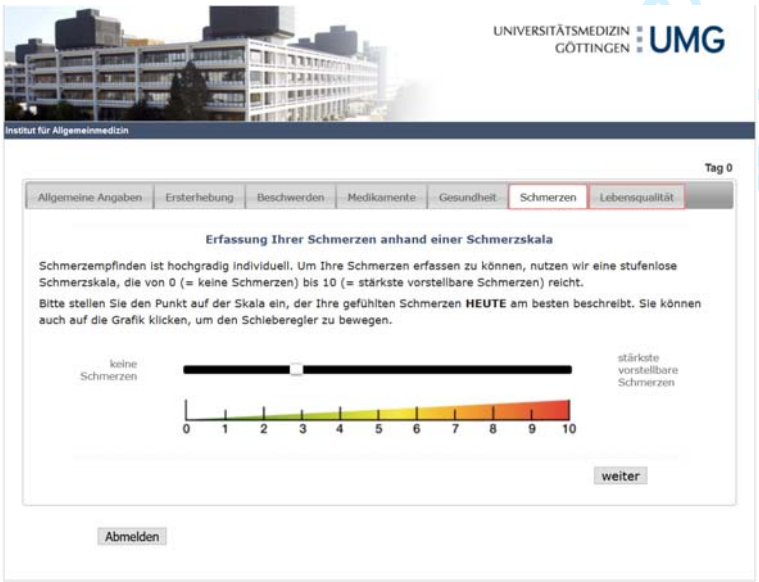


EQ-5D-5L (excerpt)

Participants evaluate their current state of health (only for the validation study)

Visual analog scale

Participants assess pain intensity on a scale of 0 to 10 (only for the validation study)



UTI-SIQ-8

Participants evaluate severity of symptoms and impairment