THERAPEUTIC ADVANCES in
Infectious Disease

Systematic Review

Atlas of patient-reported outcome measures, nomograms and scoring systems used in simple and complicated urinary tract infections: a systematic review

Ther Adv Infect Dis

2025, Vol. 12: 1–34

DOI: 10.1177/20499361251328258

Nicholas L. Harrison, Arthur W. Day, Zafer Tandogdu, Gernot Bonkat and Bhaskar K. Somani

Abstract

Background: Urinary tract infections (UTIs) are common and result in a significant impact on quality of life (QoL). Despite their prevalence, there seems to be a lack of evidence around patient-reported outcomes and measuring tools such as scoring systems and nomograms in UTIs. Patient-reported outcome measures (PROMs) help us measure patient-related symptoms and their QoL.

Objective: Our literature review shows an up-to-date "atlas" of the available PROMs, nomograms and scoring systems that can help clinicians in treatment decisions and track treatment response in patients with UTIs.

Design: Systematic review of the literature.

Data sources and methods: A comprehensive systematic review was carried out on PubMed Medline, Scopus and CINAHL, according to PRISMA guidelines, using search terms related to PROMs, nomograms and scoring systems used in simple and complicated UTIs. A narrative review was done, and tool characteristics, accuracy, validation, and applicability were collected and summarized.

Results: Sixty-two articles (with 16 different PROMs) were included in the final review. These included generic tools such as the 36-Item Short Form Health Survey and specific tools like the Acute Cystitis Symptom Score and Recurrent Urinary Tract Infection Impact Questionnaire, amongst others. While scoring systems seemed to be used for severe infections such as Fournier's gangrene and emphysematous pyelonephritis, nomograms were primarily used for diagnosis and risk prediction. PROMs are useful tools and have utility within the management of patients with UTIs, but further clarity is needed as to which of these tools is most appropriate for each type of UTI as each offer their respective advantages and disadvantages.

Conclusion: This atlas is the first comprehensive review of PROMs, scoring systems and nomograms in the management of UTIs. While PROMs improve patient care, further standardisation, external validation and accuracy are needed. While nomograms and scoring systems can help clinicians, these must be tailored to individual patients based on their specific clinical scenarios.

Trial registration: PROSPERO registration number CRD42025625865.

Keywords: atlas, infection, nomograms, PROM, review, sepsis, UTI

Received: 19 August 2024; revised manuscript accepted: 25 February 2025.

Correspondence to:
Bhaskar K. Somani
University Hospital Southampton NHS Foundation Trust, Southampton, UK

Department of Urology, University Hospital Southampton, Tremona Road, Southampton SO16 6YD, UK
bhaskarsomani@yahoo.com

Nicholas L. Harrison
Arthur W. Day
Department of Urology, Mersey and West Lancashire Teaching Hospitals NHS Trust, Prescot, Merseyside, UK

Zafer Tandogdu
Department of Urology, University College London Hospitals, London, UK

Gernot Bonkat
Department of Urology, Alta Uro AG, Basel, Switzerland

Background

Urinary tract infections (UTIs) are amongst the most common bacterial infections,[1,2] with an estimated annual incidence of 12.6% in females and 3% for men[3] Between 50% and 60% of females will have a UTI in their lifetime.[4] Furthermore, UTIs can affect all ages and their presentation can vary immensely. Uncomplicated UTIs often resolve quickly, especially in young females. Contrastingly, UTIs affecting elderly patients can result in significant morbidity.[5] In addition, UTIs can often recur, with approximately 25% of females with UTI going on to suffer a further UTI within 6 months.[1–3,6,7] Recurrent UTI (rUTI) can have a significant effect on patients, affecting quality of life (QoL) and daily activities, leading to a reduced quality of both intimate and social relationships, reduced self-esteem and impaired capacity for work.[7–9]

Classification of UTI is important. They are classified according to the location, whether they are confined to the lower urinary tract or upper urinary tract, as well as to whether they are complicated or uncomplicated.[3] Of note, any UTI affecting male patients is classified as complicated. An uncomplicated UTI is one occurring in a non-pregnant patient in the absence of structural or functional abnormality, who has not had instrumentation of the urinary tract, either through catheterisation or surgical instrumentation.[3] Further, UTI can be recurrent, defined as at least three UTIs in a year or two UTIs in 6 months,[9] or associated with a catheter, referred to as a catheter-associated UTI (CAUTI).

There is a paucity of literature concerning the impact of UTIs on patients' QoL.[8] Patient-reported outcomes (PROs) are studied throughout medicine and have become increasingly utilised, with the volume of academic literature concerning them increasing rapidly.[10–14] These PROs are measured using patient-reported outcome measures (PROMs). These are instruments or tools, usually patient completed questionnaires, used to provide information from a patient perspective, without interpretation of a clinician, giving valuable information regarding a patient's symptoms, health-related quality of life (HRQoL) and functional status.[13] By including the patient's perspective, it allows for more holistic and patient-centred care,[13] which can facilitate shared decision making, monitor symptoms and improve overall patient care.[15] Generally, PROMs can be characterised as disease specific and generic.[10,14] Generic PROMs allow for comparison across several patient groups and settings,[10] whereas disease-specific PROMs tend to inherently possess higher validity.[14] It has been recommended that using disease-specific and generic PROMs in conjunction provides the broadest range of information. PROMs in urology have been studied in a number of sub-specialities, including endourology,[16,17] andrology,[18] reconstructive urology[19,20] and oncology.[21–24] There is, however, little literature concerning PROMs regarding UTI. Piontek et al.[25] recently carried out a systematic review and analysis of PROMs specifically for uncomplicated UTI in women, and Bermingham and Ashe[26] carried out a systematic review in 2012 to specifically assess QoL measures available for patients with UTI.

In addition to PROMs, we have compiled the current scoring systems and nomograms used in relation to UTIs. Scoring systems use different physiological, biochemical and radiological variables to provide an objective measurement of the severity of an illness.[27] Nomograms are a pictorial representation of a complex mathematical formula. Medical nomograms use biochemical and clinical variables to predict the probability of an event, such as death, for a given individual.[28] Scoring systems in medicine traverse the full spectrum of specialities and disease severity, with an estimated 250,000 available for use.[29]

The aim of this study was to conduct a review of the literature to compile an up-to-date "atlas" of the available PROMs, nomograms and scoring systems that can be used in patients with urinary tract infections, which are common and can in. We aim to provide the clinician with an overview of the available tools that can be used when managing patients with UTI, both in terms of disease severity and the impact of UTIs on patients' QoL. We also hope this atlas will serve as a reference point for future researchers and clinicians assessing the psychosocial impact of UTI on patients.

Methodology

A comprehensive systematic review of the literature was carried out using the clinical databases PubMed Medline, Scopus and CINAHL, according to Preferred Reporting Items for

Systematic Review and Meta-Analysis (PRISMA) guidelines.[30] The review was registered with PROSPERO (Registration number CRD 42025625865). Search protocols were tailored to each of the databases. Search terms can be found in Appendix 1. Boolean operators "AND"/"OR" were used to refine results. Due to the heterogenous nature of the reported data, quantitative analysis was not possible and therefore a narrative review was carried out. Bibliographies of included studies were manually searched to identify other relevant articles. Screening of articles was carried out by authors NH and AD, with queries regarding articles answered by author BKS. An assessment of the risk of bias of studies was made using Cochrane risk of bias tools.

The PICO statement for this review is as follows:

P = All patients with UTI (uncomplicated acute urinary tract infection, complicated urinary tract infection, rUTI, CAUTI, pyelonephritis, emphysematous pyelonephritis (EP), emphysematous cystitis, Fournier's gangrene (FG), epididymitis, epididymoorchitis, prostatitis and urethritis).

I = PROMs, nomograms and scoring systems used for patients with UTI.

C = Not applicable.

O = Which PROMs, nomograms and scoring systems are currently available for UTI and what are their benefits and drawbacks.

Evidence acquisition: Criteria for considering studies for this review

Inclusion criteria:

1. All articles written in the English language
2. Patients of all age groups with UTI, where a PROM, nomogram or scoring system was used and assessed in the English language

For this review, we did not include PROMs, scoring systems or nomograms used to assess patients with urosepsis specifically. This decision was made due to the large volume of available scoring systems and nomograms for urosepsis, which exceeded an acceptable amount for this review. Further work will focus specifically on urosepsis.

Results

A total of 16 different PROMs were identified; we identified studies where the Short form-36 health survey (SF-36) was used for both acute uncomplicated and recurrent UTI (Figure 1). These PROMs, their characteristics, advantages and drawbacks are summarised in Tables 1 to 4. Externally validated tools are highlighted in green. Figure 2 gives an overview of the number of PROMs, nomograms and scoring systems used in each sub-category of UTI.

Patient-reported outcome measures

Acute uncomplicated UTI

Ten PROMs were identified that were used to assess patients with acute uncomplicated UTI[31–40] are summarised in Tables 1 and 2. The activity impairment assessment (AIA) was the first UTI-specific PROM and was developed by Wild et al. in 2005,[31] based on an existing work productivity measure.[49] This PROM was designed to assess the degree to which work or normal activities had been impaired as a result of a UTI. The data for the validation study for the AIA came from an existing clinical trial, with the psychometric properties of the PROM assessed by the pattern of association with the Kings health questionnaire (KHQ), which is a validated PROM used to assess the impact of urinary incontinence on female patients' QoL.[50] The AIA is a 5-item questionnaire, making it quick to complete. It has also been translated to the French language and been externally validated. Despite its rigorous study design, with a reasonable sample size of 326 patients, plus its ease of use, it has not been studied widely in the literature.

The UTI symptoms assessment questionnaire (UTISA) is a 14-item UTI-specific PROM designed specifically for females with UTI and developed by the same authors of the AIA.[32,31] Data for the UTISA[32] validation study came again from a clinic trial. The UTISA is designed to assess the severity and bother of seven key UTI symptoms. It was again compared against the KHQ and has been externally validated. Is should however be noted that in their systematic review,

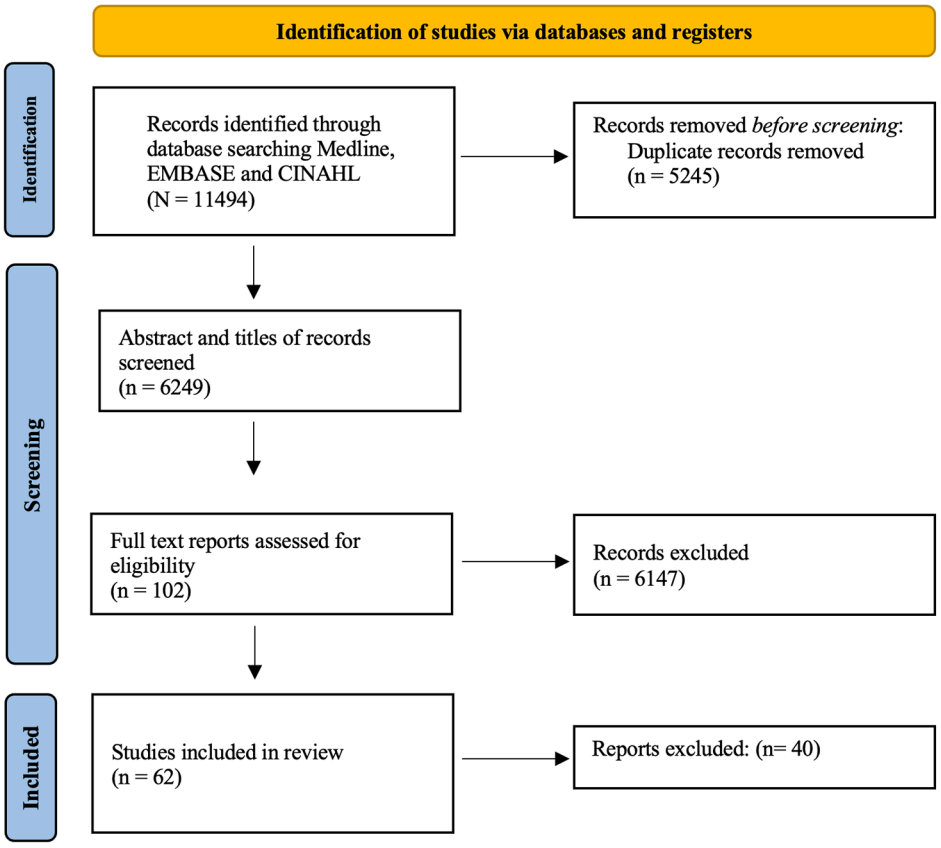

Figure 1. PRISMA flowchart of the included studies.
PRISMA: preferred reporting items for systematic review and meta-analysis.

Piontek et al.[25] found that the PROM had insufficient content validity.

Ernst et al.[33] in 2006 used the quality of well-being (QWB) scale to assess QoL in patients with acute uncomplicated UTI. This is a 71-item generic PROM already widely used and taking up to 20 min to complete. The study did not aim to assess the validity or accuracy of the PROM, and we did not find QWB used elsewhere in UTI patients, possibly due to the prolonged administration time of the PROM. Another generic PROM, the Health Utilities Index Mark 2 measure of health-related quality of life (HUI2), was used by Maxwell et al.[34] in 2009 to assess the HRQoL of elderly care home residents. They used linear regression models to assess the association between patient characteristics, including UTI and that of HRQoL. They found that UTI had a statistically significant negative impact on HRQoL. The PROM itself is 31 items long, available in multiple languages and states that it can identify 24,000 'individual health states'.[34] Regardless, UTI was only one of several patient characteristics studied in this article, and there is no further literature describing the use or external validation of the HIU2 in UTI patients.

The Philadelphia Geriatric Center Morale Scale (PGCMS) is a generic PROM designed for elderly patients and is a 17-item questionnaire designed to assess morale of patients.[35] The authors found that UTI significantly reduced morale. However, as with the QWB and HUI2, there is no other literature showing its use in assessing UTI patients. In 2014, Alidjanov et al.[36] produced the Acute cystitis symptoms score (ACSS). This is an 18-point, self-administered questionnaire designed to aid in clinical diagnosis and follow-up of acute uncomplicated cystitis (AUC) in women, including questions regarding symptoms of UTI and QoL. It has been found to be highly sensitive (94%) and specific (90%) in diagnosing UTI and has been validated in

Table 1. Patient-reported outcome measures in acute uncomplicated UTI.

Author, year	Tool and type	Original language	Available language	Target population	Mode of administration	Recall period	Description
Wild et al. 2005[31]	Activity impairment assessment (AIA) *UTI specific*	English (USA)	English, French	Specifically female LUTS in UTI	Self-administered	24 h	Five-item questionnaire assessing the amount of time, over the previous 24 h, that the patient's work or regular activities have been impaired as a result of their UTI. Responses on 5-point Likert-type scale
Clayson et al. 2005[32]	UTI symptoms assessment questionnaire (UTISA) *UTI specific*	English (USA)	Thirteen languages Includes Chinese and English	Females with UTI	Self-administered	24 h	14-item questionnaire regarding the severity and bother of seven key UTI symptoms. Responses on a 4-point Likert-type scale
Ernst et al. 2005[33]	Quality of Well-Being scale (QWB) *Generic*	English (USA)	English, Chinese, German, Vietnamese	All adult patients	Interviewer administered	3 days	71-item questionnaire. Measures overall health and well-being over the areas: physical activities, social activities, mobility, and symptom/problem complexes
Maxwell et al. 2009[34]	Health utilities index mark 2 (HUI2) *Generic*	English (Canada)	Afrikaans, Bulgarian, Chinese, Croatian, Czech, Danish, Dutch, Finnish, Flemish, French, German, Greek, Hebrew, Hungarian, Italian, Japanese, Korean, Malay, Norwegian, Polish, Portuguese (European and Brazilian), Romanian, Russian, Serbian, Slovak, Spanish, Swedish, Tamil, Thai, Turkish and Vietnamese	All adult patients	Self or interviewer -administered	Not stated	31-item questionnaire containing 7 different 'attributes': sensation, mobility, emotion, cognition, self-care, pain and fertility Can identify 24,000 unique 'health states' Assesses general health status and HrQoL Responses on a Likert-type scale
Eriksson et al. 2010[35]	Philadelphia Geriatric Center Morale Scale (PGCMS) *Generic*	English (USA)	Hebrew, Japanese, Korean, Spanish, Swedish, Turkish	Elderly patients aged 70 and above	Interviewer administered or Self-administered	Not stated	17-item questionnaire. 3 factors emerge: Agitation, attitude towards own ageing and lonely dissatisfaction. Responses in a Yes/No format.

(Continued)

Table 1. (Continued)

Author, year	Tool and type	Original language	Available language	Target population	Mode of administration	Recall period	Description
Alidjanov, 2014[36]	Acute cystitis symptom score (ACSS) *UTI specific*	Uzbek, Russian	English, Chinese, French, German, Greek, Hungarian, Italian, Polish, Portugese, Romanian, Spanish, Swedish, Tajik, Ukranian, Uzbek, Russian	Females	Self-administration	24 h	18-item self-reporting questionnaire for clinical diagnosis and follow-up of acute uncomplicated cystitis (AUC) in women, including questions regarding symptoms of UTI and QoL Some responses on a 4-point Likert-type scale, some elements in Yes/No format
Holm et al. 2017[37]	Symptom Diary *UTI specific*	Danish	Danish, English	Females	Self-administration	7 days	21-item questionnaire. Eight items regarding symptom severity, eight items regarding symptom bothersomeness and five items regarding daily activities. Responses on 4-point Likert-type scale
Alanzi et al. 2020[38]	EQ-5D-3L *Generic*	English	150 languages worldwide	All	Self - administered	Not stated	16-item questionnaire that has 2 pages, the EQ-5D descriptive system and the EQ visual analogue scale (EQ VAS). Consists of five dimensions: mobility, self-care, usual activities, pain/discomfort and anxiety/depression. Responses on a Likert-type scale
Gágyor et al. 2021[39]	Urinary tract infection-Symptom and Impairment Questionnaire (UTI-SIQ-8) *UTI specific*	German	English, German	Females	Self-administered	Same day	Eight-item questionnaire, 4 questions for symptoms and 4 for impact on QoL Responses on a 5-point Likert-type scale
Thompson et al. 2023[40]	Short form-36 health survey (SF-36) *Generic*	English (USA)	English, Spanish, French, Swedish, Korean, German, Dutch, Portuguese, Chinese, Czech, Finnish, Danish, Hungarian, Hebrew, Italian, Japanese, Norwegian, Polish, Romanian, Slovak, Russian, Afrikaans.	All adult patients	Self – administered	1 week	36-item questionnaire containing 8 health profiles: Physical functioning, social functioning, role limitations, bodily pain, general medical health, mental health, role limitations, vitality, general health. Assesses overall health-related QoL Responses on Likert-type scales.

Externally validated tools are highlighted green.
HrQoL, health-related quality of life; LUTS, lower urinary tract symptoms; QoL, quality of life; UTI, urinary tract infection.

Table 2. Patient-reported outcome measures in acute uncomplicated UTI continued.

Author, year	Tool and type	Interpretation	Advantages	Drawbacks	External validation
Wild et al. 2005[31]	AIA *UTI specific*	Scores range from 0 to 20 with higher scores denoting higher impairment	• Highly and statistically significant correlation with validated measure (Kings Health Questionnaire) • Short and easy to use • Specific to UTI	• Kings health questionnaire is validated for female LUTS, not specifically UTI	Yes
Clayson et al. 2005[32]	UTISA *UTI specific*	Score of >3 has good predictive value for acute uncomplicated UTI (sensitivity of 87.0%, and specificity of 93.1%)	• Original study had small sample size of 33, validation study in China (Chang et al 2015[41]) had a larger sample size of 293 • Specific to UTI	• Small sample size[38] • Kings health questionnaire is validated for female LUTS, not specifically UTI	Yes
Ernst et al. 2005[33]	QWB *Generic*	Four domain scores of the questionnaire are combined and a result between 0 and 1 is generated. 1 is optimum health, 0 is death	• Widely used and well validated across multiple health conditions across multiple countries • Gives broad assessment of HrQoL • More specific for acute illnesses	• 20 min to complete • Interviewer administered • Not specific to UTI	Yes (but not for UTI)
Maxwell et al. 2009[34]	HUI2 *Generic*	Seven domain scores of the questionnaire are combined and a result between 0 and 1 is generated. 1 is optimum health, 0 is death	• Widely used and well validated across multiple health conditions across multiple countries • Gives broad assessment of HrQoL	• Tool not readily available, requires payment for use • This version of the HUI was originally developed for paediatric cancer • Complicated tool • Not specific to UTI • Used more for chronic illnesses	Yes (but not for UTI)
Eriksson et al. 2010[35]	PGCMS *Generic*	As a general guideline, scores at 13 to 17 would be considered high scores on the morale scale, 10 to 12 fall within the mid-range and scores under 9 are at the lower end	• Quick to complete • acceptable level of reliability, validity, and a high internal consistency	• Not specific to UTI • Specific only to elderly patients	Yes (but not for UTI)

(Continued)

Table 2. (Continued)

Author, year	Tool and type	Interpretation	Advantages	Drawbacks	External validation
Alidjanov, 2014[36]	ACCS *UTI specific*	A sum score of 6 or higher of all the six ACSS typical symptoms is highly sensitive and specific for UTI (94% sensitivity, 90% specificity)	• Assessment of the severity of symptoms, their effect on QoL and the differentiation of cystitis from other urogenital disorders • Short and easy to use • Repeatedly validated in multiple languages • Specific to UTI		Yes
Holm et al. 2017[37]	Symptom Diary *UTI specific*	Not stated in article	• Covers broad range of different dimensions of patient-experienced UTI not addressed in other tools • Specific to UTI	• No external validation • Questionnaire only available after written permission from authors	No
Alanzi et al. 2020[38]	EQ-5D-3L *Generic*	In the EQ-5D descriptive system, a standardized utility index (UI) score ranging from 0 (representing death) to 1 (representing full health) is generated. For the EQ-VAS, the patient records their health status on a vertical VAS ranging from "Best imaginable health state" (100) to "Worst imaginable health state" (0)	• Widely used and well validated across multiple health conditions across multiple countries • Gives broad assessment of HrQoL • Quick to complete	• Not as comprehensive as other tools • Not specific to UTI	Yes (but not for UTI)
Gágyor et al. 2021[39]	UTI-SIQ-8 *UTI specific*	Not stated	• Very short and easy to use • Online version available • High reliability and validity when compared with validated tools EQ-5D and VAS • Specific to UTI	• Authors do not advise users to use the UTI-SIQ-8 for individual assessment at this time	No
Thompson et al. 2023[40]	SF-36 *Generic*	Score out of 100, Higher scores indicate better overall heath.	• Widely used and well validated across multiple health conditions across multiple countries • Gives broad assessment of HrQoL • Online version available	• Longer to complete • Not specific to UTI • Used more for chronic illnesses • Complicated to calculate score	Yes

Externally validated tools are highlighted green.
ACCS, Acute cystitis symptoms score; AIA, Activity impairment assessment; EQ VAS, EQ visual analogue scale; HrQoL, health-related quality of life; LUTS, lower urinary tract symptoms; PGCMS, Philadelphia Geriatric Center Morale Scale; QoL, quality of life; QWB, Quality of Well-Being scale; SF-36, 36-Item Short Form Health Survey; UTI, urinary tract infection; UTISA, UTI symptoms assessment questionnaire; UTI-SIQ-8, Urinary tract infection-Symptom and Impairment Questionnaire.

Table 3. Patient-reported outcome measures in recurrent UTI.

Author, year	Tool and type	Original language	Available language	Target population	Mode of administration	Recall period	Description
Renard et al. 2014[42]	Hospital Anxiety and Depression (HAD) scale *Generic*	English	115 languages	Patients attending hospital outpatient clinics	Self-administered	1 week	14-item questionnaire. Seven questions for anxiety and seven questions for depression Responses on a 4-point Likert-type scale.
Renard et al. 2014[42]	Leicester impact scale *LUTS specific*	English	English	Patients with urinary symptoms	Self-administered	Not stated	21-item questionnaire comprising 3 areas of impact: Impact on activities, feelings and relationships. Responses on a 3-point Likert-type scale
Ennis et al. 2018[43]	Short form-36 health survey (SF-36) *Generic*	English (USA)	English, Spanish, French, Swedish, Korean, German, Dutch, Portuguese, Chinese, Czech, Finnish, Danish, Hungarian, Hebrew, Italian, Japanese, Norwegian, Polish, Romanian, Slovak, Russian, Afrikaans.	All adult patients	Self – administered	1 week	36-item questionnaire containing 8 health profiles: Physical functioning, social functioning, role limitations, bodily pain, general medical health, mental health, role limitations, vitality, general health Assesses overall health-related QoL Responses on Likert-type scales.
Wagenlehner et al. 2018[44]	SF-12v2. *Generic*	English	205 languages	All adult patients	Self-administered	4 weeks	12-item questionnaire assessing the same 8 health domains as the SF-36: Physical functioning, social functioning, role limitations, bodily pain, general medical health, mental health, role limitations, vitality, general health Assesses overall HRQoL Responses on Likert-type scales.

(Continued)

Table 3. (Continued)

Author, year	Tool and type	Original language	Available language	Target population	Mode of administration	Recall period	Description
Croghan et al. 2021[45]	The recurrent urinary tract infection health and functional impact questionnaire (RUHFI-Q) *UTI specific*	English	English	Pre-menopausal female patients with recurrent UTI	Self-administered	24 h	16-item questionnaire comprising the themes: frequency of UTIs, duration of symptoms, time to full recovery, specific symptoms of UTI, constitutional symptoms, impact on work/education, impact on leisure activities, impact on interpersonal relationships, impact on sexual relationships, psychological aspects and implications of treatment
Newlands et al. 2023[46]	The Recurrent Urinary Tract Infection Symptom Scale (RUTISS) *UTI specific*	English	English	Female patients with recurrent UTI	Self – administered	24 h	28-item questionnaire that assesses recurrent UTI symptoms over time. These focus on frequency, a global rating of change scale, a urinary symptoms subscale, a UTI pain subscale, and an additional section evaluating critical clinical features such as diabetes and pregnancy Responses on a scale from 0 to 10 (0 being not present, 10 being severe)
Newlands et al. 2023[47]	The Recurrent UTI Impact Questionnaire (RUTIIQ) *UTI specific*	English	English	Female patients with recurrent UTI	Self – administered	24 h	30-item questionnaire consisting of five subscales: personal wellbeing (4 items), social impact (5 items), work and activity interference (7 items), sexual wellbeing (4 items), and patient satisfaction (10 items). Responses on 11-point Likert type scales

Externally validated tools are highlighted green.
HrQoL, health-related quality of life; SF-12v2, short form – 12 version 2; UTI, urinary tract infection.

Table 4. Patient-reported outcome measures in recurrent UTI continued.

Author, year	Tool and Type	Interpretation	Advantages	Drawbacks	External validation
Renard et al. 2014[42]	Hospital Anxiety and Depression (HAD) scale *Generic*	Scores from questions are compiled into a total score to assess levels of anxiety and depression. 0–7 = normal 8–10 = borderline case 11–21 = abnormal case	• Shorter questionnaire • Widely used and well validated across multiple health conditions across multiple countries	• Not specific to rUTI • Specific for mental health	Yes (but not for UTI)
Renard et al. 2014[42]	Leicester impact scale *LUTS specific*	Scale divided into four ranges: 0–14, 15–20, 21–30, and 31–42. A score of > 14 indicated that the patient had some degree of functional or social handicap, a score of > 20 was suggestive of a major social or functional handicap, and scores > 31 indicated major social and functional handicaps	• Has been shown to have good validity and reliability in patients with lower urinary tract symptoms	• Not specific to rUTI • Not validated for UTI • Self administered in this study, initially designed to be interviewer administered	No
Ennis et al. 2018[43]	SF-36 *Generic*	Score combined and normalised to calculate a score out of 100, Higher scores indicate better overall heath	• Widely used and well validated across multiple health conditions across multiple countries • Gives broad assessment of HrQoL • Online version available	• Longer to complete • Not specific to UTI • Used more for chronic illnesses • Complicated to calculate score • Small study size used in this study[48]	Yes
Wagenlehner et al. 2018[44]	SF-12v2. *Generic*	Score combined and normalised to calculate a score out of 100, higher scores indicate better overall heath	• Short questionnaire – 12 points • Large study carried out across five countries • SF-12v2 Takes less than 2 min to complete • Widely used and well validated across multiple health conditions across multiple countries • Gives broad assessment of HrQoL • Online version available	• Not specific to UTI • Used more for chronic illnesses • Complicated to calculate score	Yes (but not for UTI)

(Continued)

Table 4. (Continued)

Author, year	Tool and Type	Interpretation	Advantages	Drawbacks	External validation
Croghan et al. 2021[45]	The recurrent urinary tract infection health and functional impact questionnaire (RUHFI-Q) *UTI specific*	Total score out of 122, authors suggest this be interpreted on a continuum, from mild to severe QoL impact	• Shorter questionnaire (16 items)	• No psychometric evaluation • No external validation • Small sample size – 10 patients	No
Newlands et al. 2023[46]	The Recurrent Urinary Tract Infection Symptom Scale (RUTISS) *UTI specific*	Higher scores associated with worse symptoms	• First recurrent UTI specific score • Excellent reliability and validity • Follows COSMIN recommendations • Uses 11 point scale, shown to have higher reliability and validity	• Study included predominantly Caucasian, native English speakers • First study, not externally validated	No
Newlands et al. 2023[47]	The Recurrent UTI Impact Questionnaire (RUTIIQ) *UTI specific*	Higher scores in the first 4 subscales indicate lower QoL. Higher score in patient satisfaction subscale indicates greater satisfaction with care	• First recurrent UTI specific score • Excellent reliability and validity • Follows COSMIN recommendations • Uses 11 point scale, shown to have higher reliability and validity • Data from large sample size	• Study included predominantly Caucasian, native English speakers • First study, not externally validated	No

HrQoL, health-related quality of life; rUTI, recurrent UTI; SF-12v2, short form – 12 version 2; SF-36, 36-Item Short Form Health Survey; UTI, urinary tract infection.

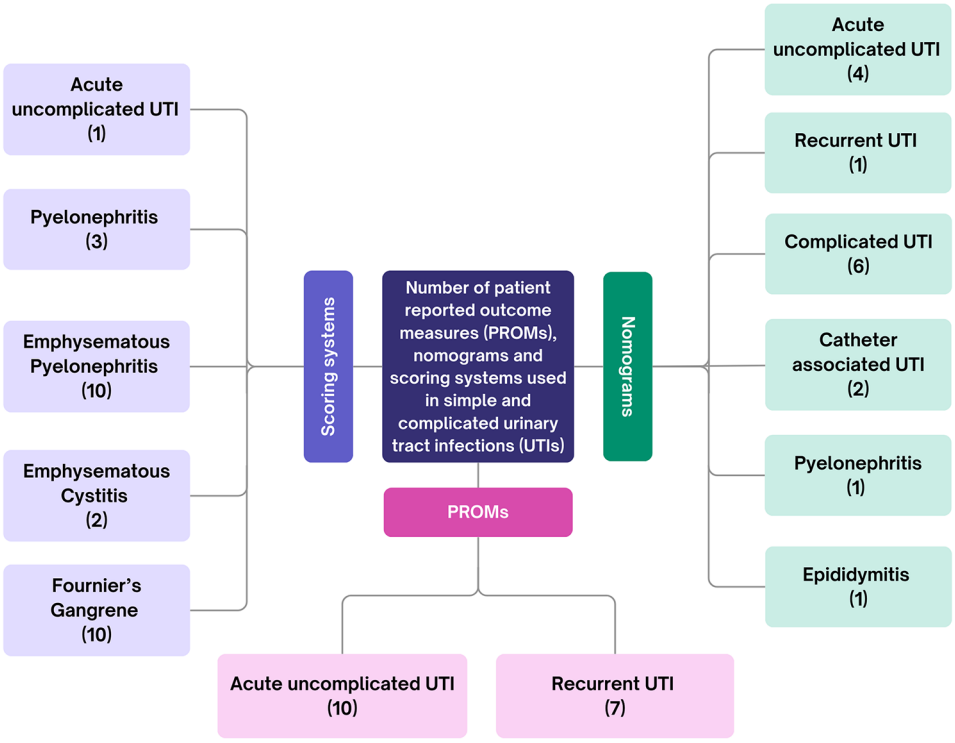

Figure 2. Summary of the number of PROMs, nomograms and scoring systems identified for each sub-category of UTI.
PROM, patient reported outcome measures; UTI, urinary tract infection.

multiple languages. While acting as a diagnostic tool, the ACSS also assesses the impact of UTI on patients' HRQoL. It has been described as having sufficient content validity and alongside the UTI-SIQ-8, was one of only two PROMs recommended for use in acute uncomplicated UTI in females by Piontek et al.

In 2017, Holm et al.[37] published their work on a UTI-specific PROM in the form of a symptom diary. This covers a broad range of different dimensions of patient-experienced UTI not addressed in other PROMs and shows good content validity as well as being psychometrically validated. However, the PROM itself is only available for use after written confirmation by the authors and we could not identify any external validation in the literature. Alanazi et al.[38] in 2020 evaluated the HRQoL of women with acute UTI using the generic PROM the EQ-5D-3L, an extensively validated and robust PROM developed by the EuroQoL group. The EQ-5D-3L consists of two pages: the EQ-5D descriptive system and the EQ visual analogue scale (EQ VAS). The EQ-5D sections collect PRO information concerning mobility, self-care, usual activities, pain/discomfort and anxiety/depression. The EQ VAS consists of a patient-rated numerical score out of 100 for a patient's perceived overall health. This combination allows for a broad range of information concerning patients' HRQoL. Although this PROM has been externally validated across a number of conditions, it has not been externally validated for UTI.

As previously mentioned, the UTI-SIQ-8, developed by Gágyor et al. in 2021,[39] is another PROM that was recommended for use by Piontek et al.[25] This PROM has been shown to have high reliability and validity when compared with the validated tools EQ-5D and VAS and is available in an online version. Of note, the authors did not recommend use in clinical practice at the time of publication, perhaps whilst awaiting external validation. This tool is short, only eight items long, with four questions concerning UTI symptoms and four concerning impact on QoL. The final PROM that we identified was the short form-36

(SF-36) survey, that was used in a 2023 study by Thompson et al.[40] assessing activity impairment, health-related quality of life and productivity in patients with UTI. The SF-36, like the EQ-5D-3L, is a well-validated PROM that is used across a number of conditions, although these tend to be chronic conditions primarily. It is a longer tool, with 36 items producing a total score out of 100, although it is noted that calculation of the final score is difficult.

Recurrent UTI

Seven PROMs were identified that were used in patients with rUTI,[42–46] these are summarised in Tables 3 and 4. Renard et al.[42] carried out a study involving 575 patients where they utilised the Hospital Anxiety and Depression (HAD) scale and Leicester impact scale, to assess the impact of rUTI on patients' QoL. The HAD is a generic PROM that is over 30 years old and has been widely used and well validated. It assesses levels of anxiety and depression, and was designed for patients in an outpatient setting. It is quickly completed, with only 14 questions. It has not been used elsewhere in patients with UTI but has been recently used in patients with lower urinary tract symptoms (LUTS).[51] The Leicester impact scale was developed in 2004 by Shaw et al.[52] as a PROM to be used to assess the HRQoL of patients with LUTS. The initial study revealed high levels of internal consistency and acceptable construct validity, however, this PROM was interviewer administered in this initial study and was patient-administered in the study by Renard et al.[42]

A generic PROM that was used in both acute uncomplicated and rUTI patient populations was the SF-36. For rUTI patients, it was assessed in the study by Ennis et al.[43] in 2018. This was a small study with a sample size of 85 patients. As the SF-36 is more often used for chronic conditions, rUTI is perhaps a more suitable population to use the SF-36. Wagenlehner et al.[44] used the Short form – 12 version 2 (SF-12v2) in their GESPRIT study assessing the effect of rUTI on QoL. The SF-12v2 is a shortened version of the SF-36, 12 items long and taking only 2 min to complete. It is widely used and well validated across multiple health conditions across multiple countries, although this is the first study that we identified that used this PROM.

Since 2021, we identified three rUTI-specific PROMs that have been developed. The first of which is the recurrent urinary tract infection health and functional impact questionnaire (RUHFI-Q), developed by Croghan et al.[45] This article reports on the development and feasibility testing of the PROM, but unfortunately is a small sample size of 10 patients, it has yet to undergo psychometric testing or external validation. The two most recent PROMs for patients with rUTI were developed by Newlands et al.[46,47] The Recurrent Urinary Tract Infection Symptom Scale (RUTISS) is a PROM focusing on symptoms and pain associated with rUTI. The 28-item questionnaire includes an assessment of UTI symptom frequency, a global rating of change scale, a urinary symptom subscale, a UTI pain subscale, and an additional section evaluating critical clinical features such as diabetes and pregnancy. It shows excellent reliability and construct validity. The Recurrent UTI Impact Questionnaire (RUTIIQ)[47] is a 28-item questionnaire that assesses the patient-reported psychosocial impact of living with rUTI symptoms and pain. It has been developed by the same team as that of the RUTISS and instead focused on the impact of rUTI on HRQoL. It shows good psychometric properties and construct validity. Of note, development of the PROM was rigorous, with a heterogeneous and international patient cohort utilised. These two PROMs have yet to be externally validated, but we predict that they will provide a broad assessment of the impact of rUTI on patients from a symptomatology and QoL perspective.

Other types of UTI

We did not identify other examples of PROMs being used in patients with other types of UTI. In their 2023 qualitative analysis, Suijker et al.[53] found that necrotising soft tissue infections have a significant impact on patients' HRQoL similar to that of burns victims. However, a specific PROM was not used in this study.

Scoring systems and nomograms

Acute uncomplicated UTI

The accuracy of most nomograms was measured using the C-index. These scores range from 0.5 to

1.0, with a score of 0.7 or higher generally accepted as a good predictive model.[54] Scoring systems analysis was tested using receiver operating characteristic (ROC) curves and area under the curve (AUC) values. Again, AUC values range from 0.5 to 1.0, with a value of 0.5 indicating that the test is no better than random chance. Values of 0.8 and above are generally thought to correspond to a good predictive model.[55]

We identified six nomograms used in patients with acute uncomplicated UTI are summarised in Table 5.[56–61] The earliest nomogram identified was that of García-Tello et al. in 2018.[56] This nomogram was developed to predict the probability of UTI by extended spectrum beta-lactamase (ESBL) producing Enterobacteriaceae. This was a large study involving 1524 patients, with the development of the nomogram involving a development cohort and validation cohort and showing good discriminative accuracy of 79% (95% CI 0.77–0.83). It should be noted that all but select few of the nomograms and scoring systems we identified were single centre, retrospective studies, without external validation, unless specified otherwise in this article.

In 2019, Ben Ayed et al.[57] produced a scoring system to predict the risk of multi-drug resistant (MDR) organisms in community-acquired UTI. This showed an AUC score of 0.71. The total score was out of 18 and at a cut-off score of $\geqslant 12$), the specificity and PPV achieved 100%. Again, this was a single centre, retrospective study and it should be noted that rates of MDR organisms vary globally, limiting the generalisability of these two scoring systems.

In 2021, Zhang et al.[58] developed a nomogram to predict the risk of sepsis in patients with UTI, and this nomogram included 11 variables and is the first model to predict probability of sepsis in patients with UTI. It has been shown to have a reasonable AUC of 0.775 and at the optimal cut-off, reasonable sensitivity, and specificity at 0.706 and 0.701, respectively. A nomogram developed to predict UTI risk in a specific population was that developed by Li et al. in 2023.[59] This nomogram predicts the risk of UTI in children less than three years of age. This was a large study involving 1271 patients and interestingly, the authors created three different nomograms for three different clinical settings. These settings were a local clinic, medical centre and regional hospital, and the nomogram variables were altered depending on the setting, according to what investigations would be commonly available. All the nomograms were shown to be accurate with AUC's for the local clinic being 0.9133, the medical center being 0.9033 and regional hospital being 0.8933. The final nomogram identified was another developed to predict the probability of ESBL-positive UTI. Lu et al.[60] collected data over a 25-year period from a single institution and found that the nomogram had moderate accuracy (C-index 0.741). As previously mentioned, the variation of resistant organisms' from region-to-region makes generalisability of the nomogram difficult.

Complicated UTI and rUTI

We identified six nomograms and one scoring system used in patients with either rUTI or complicated UTIs[61–67] are summarised in Table 6. Cai et al.[62] developed the LUTIRE nomogram in 2014 to predict the risk of UTI recurrence within 12 months, the only nomogram identified that assessed patients regarding rUTI. It contains only six variables, is quick to calculate, and is shown to be accurate (AUC 0.85, 95% CI 0.79–0.91). Of note, LUTIRE was externally validated in a Brazilian cohort in 2020.[68]

In 2014, Van der Starre et al.[63] assessed the prognostic value of pro-adrenomedullin, procalcitonin (MR-proADM) and C-reactive protein (CRP) in predicting outcome of febrile UTI. They found that the AUC for MR-proADM was 0.83 (95% CI 0.71–0.94) and PCT was 0.71 (95% CI 0.56–0.85). CRP, erythrocyte sedimentation rate (ESR) and leucocyte count lacked diagnostic value. This was a prospective, multicentre study and the first to assess the prognostic value of MR-proADM. Lalueza et al.[64] developed a nomogram in 2019 to predict the risk of bacteraemia in patients with UTI attending the emergency department. This has been classified as a complicated UTI related nomogram as only patients that underwent blood culture were included in this retrospective study, which would have likely led to patients with more severe UTIs being included in the development of the model. The nomogram had a *C*-index of 0.793, indicating moderate accuracy of the model.

Wang et al.'s 2021 nomogram concerns UTI risk in patients with neurogenic bladder.[65] This short

Table 5. Scoring systems and nomograms in acute uncomplicated UTI.

Author, year	Nomogram name	Description	Variables/Predictors	Unique features	Advantages	Drawbacks	External validation?
García-Tello et al. 2018[56]	N/A	Nomogram to predict the probability of UTI infection by extended-spectrum beta-lactamase-producing Enterobacteriaceae (ESBL)	Seven variables included in nomogram: Age, gender, nursing home, previous antimicrobial therapy or hospitalization, recurrent UTI and non-urological invasive procedure Discriminative accuracy was 0.79 (95% confidence interval 0.77-0.83).	–	Large study – 1524 patients Accurate	Retrospective, single centre study Not externally validated	No
Ben Ayed et al. 2019[57]	N/A	Scoring system to predict the risk of multi-drug resistant organism in community-acquired UTI	Variables included: age ⩾70 years (4 points), history of diabetes mellitus (2 points), history of urinary tract surgery in the last 12 months (6 points) and previous antimicrobial therapy in the last 3 months (3 points) Area under the curve (AUC) of 0.71 (95% confidence interval (CI), 0.66–0.73, $p < 0.001$) At a cut-off point of ⩾12), the specificity and Positive predictive value (PPV) achieved 100%	–	Moderate sized study – 770 patients Easy to use Moderately accurate	Retrospective, single centre study Not externally validated	No
Zhang et al. 2021[58]	N/A	Nomogram to predict sepsis risk in patients with UTI	11 Variables include: Co-morbidities (congestive heart failure, diabetes, urine culture, red cell width (RDW), neutrophils, lymphocytes, urine protein, urine blood, APS-III score AUC 0.756 (95% CI = 0.730–0.784) At the optimal cut-off, the sensitivity and specificity were 0.706 and 0.701	First model to predict probability of sepsis in patients with UTI	Large study - 6551 patients Comparable to Acute physiology score – III (APSIII) Moderately accurate	Retrospective, single centre study Not externally validated	No
Li et al. 2023[59]	N/A	Nomogram to predict risk of UTI in children < 3 years	Variables include a combination of demographic, biochemical and radiological variables. A different combination was used depending on the clinical setting. AUC analysis for different settings was: Medical center 0.9033, Regional hospital 0.8933, Local clinic 0.9133	Three nomograms were created specific to clinical setting: medical centres, regional hospitals, and local clinics	Larger study (1271 patients) Highly accurate	Retrospective, single centre study Not externally validated	No
Lu et al. 2022[60]	N/A	Nomogram to predict the probability of extended-spectrum beta-lactamase (ESBL) positive UTI	8 variables including: Age, UTI, fever, neurological disorders, antibiotic administration, renal anomalies, vesicoureteric reflux, malnourishment C-index 0.741	Specific to ESBL+ UTI	Moderate size study – 854 patients Moderately accurate	Retrospective, single centre study from a tertiary referral centre. Some patients may have been lost to follow up given 25 year period of data Not externally validated	No

AUC, area under the curve.

Table 6. Scoring systems and Nomograms in complicated UTI and rUTI.

Author, year	Nomogram name	Description	Variables/Predictors	Unique features	Advantages	Drawbacks	External validation?
Cai et al. 2014[62]	LUTIRE	Nomogram to predict the recurrence of UTI at 12 months after initial uncomplicated UTI	Six variables included: Number of sexual partners, bowel habit, pathogen type, hormonal status, number of UTIs, antibiotic treatment. AUC – 0.85 (95% CI 0.79–0.91)	Only nomogram specific to rUTI	Easy to use Accurate Externally validated Moderate sample size – 768	Data collected over 5-year period	Yes
Van der Starre 2014[63]	N/A	Study assessing the prognostic value of pro-adrenomedullin, procalcitonin (MR-proADM) and C-reactive protein in predicting outcome of febrile urinary tract infection	The diagnostic accuracy for predicting 30-day mortality in a febrile UTI were: MR-proADM 0.83 (95% CI 0.71–0.94), Procalcitonin (PCT) 0.71 (95% CI 0.56–0.85); CRP, ESR and leucocyte count were not diagnostic	Novel blood marker – first study to assess MR-proADM in UTI	Prospective, multicentre study (35 primary care centres and 8 emergency departments) Moderate sample size – 494 patients	Only one level of MR-proADM taken when patients first admitted, hence no data on change in levels throughout the course of UTI. Not externally validated	No
Lalueza et al. 2019[64]	N/A	Nomogram assessing risk of bacteraemia in UTI presenting to emergency department	Variables: Presence of solid organ malignancy, presence of neutrophilia, C-reactive protein and presence of pyuria. C-index 0.793	Only nomogram specifically assessing risk of bacteraemia in emergency department attendees with UTI	Quick and easy to use Accurate	Only included data on those patients on whom which blood cultures were performed Single centre, retrospective study – 213 patients Not externally validated	No
Wang et al. 2021[65]	N/A	Nomogram to assess risk of UTI in patients with neurogenic bladder	Five variables included: white blood cell (WBC) in blood, Leukocyte (LEU) in urine, Urinary pH, length of stay and urination mode C-index value of 0.921 (95% confidence interval: 0.87396–0.96804)	Specific to patients with neurogenic bladder	Patients recruited from three centres Moderate sample size – 337 Externally validated Highly accurate	Retrospective study	Yes

(Continued)

Table 6. (Continued)

Author, year	Nomogram name	Description	Variables/Predictors	Unique features	Advantages	Drawbacks	External validation?
Lu et al. 2022[66]	N/A	Nomogram to asses the 90 day risk of UTI in patients undergoing radical cystectomy and urinary diversion	Four variables included: urinary diversion type, Charlson comorbidities index (CCI), presence of stricture, and prognostic nutritional index (PNI) included in the nomogram C-index was 0.823 (95% CI: 0.723–0.824)	Use of TRIPOD checklist for nomogram development Specific to patients undergoing radical cystectomy and urinary diversion	Easy to use Takes into account a broad range of patient factors Accurate	Single centre retrospective study Not externally validated	No
Buzzi et al. 2023[67]	N/A	Nomogram to predict the risk of UTI after lower gastrointestinal surgery	Variables were duration of catheterisation, age and female sex. C-index 0.71	Specific to patients undergoing lower gastrointestinal surgery	Easy to use – only three variables Moderate sized study – 330 patients	Single centre retrospective study Not externally validated End point was positive urine culture	No
Tang et al. 2023[61]	N/A	Nomogram to predict probability of UTI in geriatric patients with hip fracture	9 Variables include: Bedridden time, Albumin <35, Age >80, history of diabetes, type of fracture, type of surgery, blood glucose >6.10 mmol/L, sex, length of urinary catheterisation AUC 0.803	Specific to geriatric patients with hip fractures	Large study – 900 patients Moderately accurate	Retrospective, single centre study Not externally validated	No

Externally validated tools are highlighted green.
AUC, area under the curve; CRP C-reactive protein; rUTI, Recurrent UTI; UTI, urinary tract infection.

and easy to use, five item nomogram was shown to be highly accurate with a C-index value of 0.921 (95% confidence interval: 0.87396–0.96804). Another nomogram identified was developed to assess the 90-day risk of UTI in patients undergoing radical cystectomy and urinary diversion.[67] This nomogram was shown to be accurate with a C-index of 0.823 (95% CI: 0.723–0.824). Buzzi et al.[67] produced a nomogram designed to assess the risk of positive urine culture in patients who had undergone recent lower gastrointestinal surgery. It should be noted that the end point was positive urine culture, not UTI. Also, the C-index of 0.71 did not confer excellent accuracy. The final nomogram identified was that of Tang et al.[66] They developed a nomogram to predict the risk of UTI in geriatric patients with hip fractures in 2023. This study included 900 patients and was found to have an AUC of 0.803 and a C-Index of 0.829 (95% CI, 0.758–0.900), showing good accuracy.

Catheter associated UTI

We identified two nomograms concerning CAUTI,[65,66] summarised in Table 7. Li et al.[69] developed a nomogram to predict the risk of CAUTI in neuro-intensive care patients. The nomogram only consisted of four variables and showed good calibration and discrimination ability. The second nomogram we identified for CAUTI was developed by Wang et al.,[70] this was another quick and easy to use nomogram only including five variables. It was shown to be accurate with a C-index of 0.810.

Pyelonephritis

We identified one nomogram and three scoring systems used in patients with pyelonephritis.[71–73] These are summarised in Table 8. Fang et al.[73] developed a nomogram to diagnose pyelonephritis in paediatric patients with UTI. This easy-to-use nomogram, with only four variables, was highly accurate with an AUC of 0.89. Of note, patients who did not undergo dimercaptosuccinic acid (DMSA) scan were excluded from the study, likely leading to a bias in the patients included, who would likely have more severe UTI. In 2016, Kubota et al.[71] published a scoring system that they named the PUSH score, an acronym for P – Performance status $\geqq 3$, U – presence of Ureteral

Table 7. Scoring systems and nomograms in catheter-associated UTI.

Author, year	Nomogram name	Description	Variables/Predictors	Unique features	Advantages	Drawbacks	External validation?
Li et al. 2023[69]	N/A	Nomogram to evaluate the risk of catheter-associated urinary tract infections in neuro-intensive care patients	Four variables included: Age > 60, evidence of epilepsy, length of stay and albumin	Specific to neuro-ITU patients with catheters	Moderate sized study – 537 patients Easy to use	Retrospective, single centre study Not externally validated	No
Wang et al. 2023[70]	N/A	Nomogram used to assess risk of catheter-associated UTI in patients having undergone radical surgery for cervical cancer	Five variables included: Age, history of pre-operative chemotherapy, history of recurrent UTI, whether the patient had been catheterised before, length of catheterisation in days C-index was 0.810 (95% CI: 0.759–0.861)	Specific to patients with catheter after radical surgery for cervical cancer	Moderate sized study – 380 patients Moderately accurate Easily accessible variables	Retrospective, single centre study Not externally validated	No

AUC, area under the curve; UTI, urinary tract infection.

stones, S – Sex, female, H – Hydronephrosis. They found that the group of patients with a PUSH score of 3 points or more had a significantly higher rate of SS complications than the group of patients with a PUSH score of 1 to 2 points ($p = 0.0000036$). This is a short score, again only consisting of four variables. Following this, Valent et al.[72] used the Acute Physiology and Chronic Health Evaluation II (APACHE II), as well as the Modified Obstetric Early Warning System (MOEWS), to assess for correlation between these two scores and prolonged admission or maternal morbidity. This was the only example of the utilisation of established scoring systems being studied in pyelonephritis specifically. They found reasonable accuracy for predicting maternal morbidity in both the APACHE II (AUC 0.72) and MOEWS (AUC 0.71). This was a multicentre study involving five centres, but the sample size was small, at 123 patients. Both scores are widely used, APACHE II specifically for intensive care patients and MOEWS for pregnant patients, but not externally validated for use in pyelonephritis patients.

Emphysematous pyelonephritis

Emphysematous pyelonephritis (EP) is a condition historically associated with a high mortality rate. As a result, scoring systems are frequently employed in its management to aid in prognostication..[74] We identified ten scoring systems used in EP, studied in six articles.[75–79] These are summarised in Table 9.

Stojadinović et al.[70] developed a scoring system consisting of only three variables to predict early treatment failure in EP. It showed excellent accuracy with an AUC of 0.944; however, this was a small study with 106 patients, that included patients with pyonephrosis also. In their 2019 paper, Jain et al.[74] developed another scoring system for EP patients, this time a prognostic scoring system. Ten variables were included and a total score out of 10 was used to classify patients into favourable, intermediate, and poor prognosis groups. There was no multivariate analysis or AUC/C-index calculation, and this was a score developed from only 72 patients. Similarly, Prakash et al.[76] developed the "Stanley scoring system," consisting of five variables valued at one point each, including shock, hypoalbuminaemia, bacteraemia, thrombocytopenia and need for haemodialysis. They found that scores of four or more were associated with poor outcomes, defined as death or recurrent EP (sensitivity 95.45% specificity 98.43%, positive predictive value 95.45% negative predictive value 98.43%). This was a small study of 128 patients, and there was no AUC/C-index calculation. Krishnamoorthy et al.[77] reported their prognostic scoring system for EP in 2021. This is an 18-point scoring system that allows for risk stratification of patients. Of note, on multivariate analysis, no single factor was found to be statistically significant, there was also no AUC/C-index calculation.

Published in 2022, the GREMP study by Trujillo-Santamaria et al.[78] reported on the multi-centre study of 570 patients. They developed a scoring system consisting of six variables, with a maximum score of seven. The mortality rate was low in patients with a score of $\leqslant 3$ ($<5\%$), increased with a score $\geqslant 4$, reaching 83.3% mortality with a score of 6 and 100% with a score of seven. It showed excellent accuracy with an AUC of 0.91 (95% CI, 0.84–0.97), and it has been externally validated. This score had a rigorous development process and is highly accurate. The most recent study identified assessing scoring systems in EP was that of Bibi et al.[79] They evaluated the performance of five scoring systems (qSOFA, modified early warning score (MEWS), National Early Warning Score (NEWS), systemic inflammatory response syndrome and the global research in emphysematous pyelonephritis group (GREMP) score) in their ability to predict intensive care unit admission in patients with EP. All five scores showed high levels of accuracy to predict ICU admission with AUC 0.915, 0.895, 0.968, 0.887, and 0.846 for qSOFA, Modified Early Warning Score (MEWS), NEWS, systemic inflammatory response syndrome criteria (SIRS), and GREMP score, respectively. NEWS score was seen to be most accurate, confirming the results from Chawla et al. in 2022.[77] It should be noted that this was as small study involving only 70 patients.

Emphysematous cystitis

We identified two scoring systems that were used in patients with emphysematous cystitis, these were both studied by Chen et al. in 2023.[82] These are summarised in Table 10. In this retrospective observational study, they compared the performance of two scoring systems: the Mortality in

Table 8. Scoring systems and nomograms in pyelonephritis.

Author, year	Nomogram name	Description	Variables/Predictors	Unique features	Advantages	Drawbacks	External validation?
Kubota et al. 2016[71]	PUSH score	Scoring system used to predict risk of septic shock (SS) in patients with pyelonephritis	P – Performance Status ≧ 3 U – Presence of ureteral stones S – Sex, Female H – Hydronephrosis 0 points: 0% rate of SS, 1 points: 5.3% 2 points: 3.4% 3 points: 25.0% 4 points: 42.3%. The group of patients with a PUSH score of 3 points had a significantly higher rate of SS complications than the group of patients with a PUSH score of 1 to 2 points ($p = 0.0000036$).	Novel scoring system, specific for pyelonephritis	Quick to calculate, consisting of only 4 predictors Statistically significant increase in SS for those patients scoring 3 or 4 points, compared to 0-2 scorers.	Single centre study Smaller study – 267 patients Not externally validated	No
Valent et al. 2017[72]	Acute Physiology and Chronic Health Evaluation II (APACHE II) Modified Obstetric Early Warning System (MOEWS)	APACHE II: General prognostication score for ITU patients 24 hours after admission to ITU MOEWS: scoring system for early recognition of physical deterioration in parturiate women by monitoring their physiological parameters	Hypothesis of the study was to assess whether APACHE II or MOEWS would predict those patients presenting with pyelonephritis who would go on to have prolonged admission or maternal morbidity For prolonged admission: APACHE II: AUC 0.70 (95% CI: 0.57–0.83) MOEWS: AUC 0.67 (95% CI: 0.54–0.80] For maternal morbidity; APACHE II: AUC 0.72 (95% CI: 0.58–0.86) MOEWS: AUC 0.71 (95% CI: 0.56–0.85)	Specific for pyelonephritis in pregnancy	Multicentre study (five centres)	Retrospective study Small study – 123 patients APACHE II designed for ITU patients Not externally validated	APACHE II – widely validated, but not for this patient group
Fang et al. 2022[73]	N/A	Nomogram used to predict the risk of acute pyelonephritis (APN) in children with acute UTI	Four variables included: Fever peak >39 °C, PCT ⩾0.52 pg/mL, CRP ⩾2.86 mg/dL, and abnormal sonography AUC 0.89	Only nomogram identified to predict APN in children with UTI by combining multiple variables	Useful to predict which children may develop APN and help prevent long term sequelae of APN Highly accurate	Small study, 111 children Single centre study Those children not undergoing DMSA were excluded, risking selection bias	No

Externally validated tools are highlighted green.
AUC, area under the curve; CRP, C-reactive protein; DMSA, dimercaptosuccinic acid; UTI, urinary tract infection.

Table 9. Scoring systems and nomograms in EP.

Author, year	Nomogram name	Description	Variables/Predictors	Unique features	Advantages	Drawbacks	External validation?
Stojadinović et al. 2011[75]	N/A	Scoring system to assess early treatment failure in suppurative kidney infections (SKI)	Three variables: Recent urological procedures (13 points), sepsis syndrome (5 points) and inadequate early antibiotic (4 points) were found to have strong prognostic value in predicting the early outcome of SKI With cut off score of >5, AUC for model 0.944 (95% CI 0.867–0.983)	Focuses on treatment failure, not mortality	Easy to use Minimal variables Highly accurate	Small, single centre study – 106 patients Did not only included EP patients, also included pyonephrosis No external validation	No
Jain et al. 2019[74]	N/A	Prognostic scoring system for EP	Ten variables included, each given a score: Age >50 years – 1 $\geqslant 2$ Comorbidities – 1 TLC $\geqslant 12{,}000$ or $\leqslant 4000$ – 1 BMI $\geqslant 30$ or $\leqslant 18$ – 1 Platelets $\leqslant 100{,}000/mm^3$ – 1 Serum creatinine $\geqslant 3$ – 1 Albumin $\leqslant 2.5$ g/dL – 1 Grade of EPN II or III – 1 Sodium $\leqslant 130$ – 1 Multidrug resistance – 1 Total score out of 10 Patients were stratified into three risk categories-favourable (0–4), intermediate (5–7), and grave (8–10). mortality rates according to the risk subgroups were as follows: favourable – 0%, intermediate – 19%, and poor – 100%	Classifies EP patients into three groups according to mortality risk	Easy to use Classifies patients into low, intermediate and high risk groups	Retrospective, single centre study – 72 patients No multivariate analysis No external validation	No
Prakash et al. 2019[76]	Stanley scoring system	Prognostic scoring system for EP	Scoring system comprising following variables: shock, hypoalbuminemia, bacteraemia, thrombocytopenia, need for haemodialysis. Authors found that patients with 4 or more of these variables had worse outcomes	–	Both retrospective and prospective data	Small single centre study – 128 cases No multivariate analysis No specific prognostic data according to score	No

(Continued)

Table 9. (Continued)

Author, year	Nomogram name	Description	Variables/Predictors	Unique features	Advantages	Drawbacks	External validation?
Krishnamoorthy et al. 2021[77]	N/A	Prognostic scoring system for EP	Variables included: Age, Diabetes mellitus, unilateral/bilateral EP, level of consciousness, class of EP according to Huang and Tseng classification,[80] heart rate, blood sugar, serum creatinine, urine culture, temperature, platelet count, total white cell count, international normalised ratio (INR), palpable tender kidney, shock, BMI, serum sodium, serum albumin Scores of 1–8 were grouped in the very low-risk category. The low-risk group had a score of 9–15, the intermediate-risk group had a score of 16–20, and those with a score of >20 were the high-risk group, carrying a higher risk of mortality	–	Takes into account a broad range of parameters	Retrospective, single centre study Small sample size – 131 patients Low overall mortality rate of $<6\%$ On multi-variate analysis, no single factors were found to be statistically significant Not externally validated	No
Trujillo-Santamaria et al. 2022[78]	Global Research in the Emphysematous Pyelonephritis group (GREMP)	Mortality risk predictor score for EP	Anaemia (1 point), Thrombocytopenia (1 point), Leucocytes $>22{,}000/\mu L$ (1 point), Hyperglycaemia (1 point), Pararenal gas extension (1 point), qSOFA $\geqslant 2$ (2 points) The mortality rate is low in patients with a score of $\leqslant 3$ ($<5\%$), increased with a score $\geqslant 4$, reaching 83.3% mortality with a score of 6 and 100% with a score of 7 AUC of 0.91 (95% CI, 0.84–0.97	Multi-centre data	Highly accurate Quick and simple to calculate Multi-centre study (15 centres) – 570 patients Externally validated	Retrospective data	Yes
Bibi et al. 2023[79]	qSOFA Modified Early Warning Score (MEWS), National Early Warning Score (NEWS), Systemic Inflammatory Response Syndrome (SIRS), and Global Research in the Emphysematous Pyelonephritis group (GREMP)	Evaluation of the performance of these 5 scoring systems on predicting ICU admission for patients with EP	Combination of physiological and biochemical parameters. NEWS found to be most accurate at predicting ICU admission in patients with EP Area under the curve analysis of the 5 scoring systems for predicting ICU admission in EP were as follows: NEWS 0.968; qSOFA 0.915; MEWS 0.895; SIRS score 0.887; and GREMP score 0.846	Comparison of different scoring systems used in EP	Comparison of different scoring systems used in EP, the majority are validated and established scores Highly accurate scores Similar findings by Chawla et al. in 2022[81] – external validation	Retrospective, single centre study – 70 patients	Yes – including GREMP

Externally validated tools are highlighted green.
AUC, area under the curve; EP, Emphysematous Pyelonephritis; qSOFA: Quick Sepsis-related Organ Failure Assessment score.

Table 10. Scoring systems and nomograms in emphysematous cystitis.

Author, year	Nomogram name	Description	Variables/Predictors	Unique features	Advantages	Drawbacks	External validation?
Chen et al. 2023[82]	Mortality in Emergency Department Sepsis (MEDS) score	MEDS helps risk stratify patients into different risk groups to predict their mortality rate.	Nine variables include: Age, respiratory difficulty, presence of septic shock, platelet count, band count, age, presence of lower respiratory tract infection, nursing home residency status and mental status AUC 0.819	–	Validated and established score Highly accurate	Retrospective, single centre study Small sample size – 35 patients	Yes, but not for emphysematous cystitis patients
Chen et al. 2023	Rapid Emergency Medicine Score (REMS)	REMS predicts in-hospital mortality in nonsurgical adult patients presenting to the ED.	Six variables include: Age, mean arterial pressure, heart rate, respiratory rate, peripheral oxygen saturation and GCS. AUC 0.685	–	Validated and established score	Retrospective, single centre study Small sample size – 35 patients Not accurate	Yes, but not for emphysematous cystitis patients

Externally validated tools are highlighted green.
AUC, area under the curve; GCS, Glasgow Coma Scale.

Emergency Department Sepsis (MEDS) score and Rapid Emergency Medicine Score (REMS). These are both validated scoring systems used in infections, with this article being the first use in emphysematous cystitis patients specifically. The AUC for MEDS was 0.819 for a cut-off point of 12 points and 0.685 for REMS with a cut-off point of 10 points. This shows the higher accuracy for the MEDS, however, this was a retrospective observational study of a small cohort of 35 patients.

Fournier's gangrene

We identified eight studies assessing nine scoring systems used in patients with Fournier's gangrene (FG).[83–89] These are summarised in Table 11. As in EP, FG is a condition that carries a high mortality rate[87] and as such, scoring systems are often used for prognostication. The first scoring system developed was the Fournier's gangrene severity index (FGSI). This was developed by Laor et al.[83] in 1995. With a cut-off of nine, there was a 75% probability of death, nine or less was associated with a 78% probability of survival ($p = 0.008$). This score has been externally validated and also used to develop later scores. It shows excellent accuracy in validation studies. One such score that was developed from the FGSI was the Uludag Fournier's gangrene severity index (UFGSI) developed by Yilmazlar et al.[84] in 2010. This score uses the same parameters as the FGSI but adds age of patient and extent of gangrene to produce the new score with 11 parameters. In this study, they found the UFGSI to be highly accurate when a cut off score of nine was applied, with an AUC of 0.947. Further, they found that the UFGSI was more accurate than the FGSI ($p = 0.002$). This was a small study involving 80 patients, but the UFGSI has been externally validated. The main drawback of the score is the subjective nature of classifying the extent of the FG.

In their 2012 study, Roghmann et al.[85] assessed the performance of the age-adjusted Charlson comorbidity index (aCCI) and the surgical APGAR score (SAS) against the FGSI and UFGSI. Concerning the aCCI, which is a generic scoring system that takes into account patients' age and comorbidities to produce a 10-year mortality risk, this was shown to be accurate in FG

Table 11. Scoring systems and nomograms in FG.

Author, year	Nomogram name	Description	Variables/Predictors	Unique features	Advantages	Drawbacks	External validation?
Laor et al. 1995[83]	Fournier's gangrene severity index (FGSI)	Scoring system used to calculate risk of mortality in Fournier's gangrene	Nine variables include: temperature, heart rate, respiratory rate, serum sodium, potassium and creatinine level, haematocrit, white blood cell count and serum bicarbonate With cut-off of 9, there was a 75% probability of death, 9 or less was associated with a 78% probability of survival ($p = 0.008$)	First score developed specific for FG	Externally validated Highly accurate Specific to FG	Retrospective, single centre study Small study – 30 patients	Yes
Yilmazlar et al. 2010[84]	Uludag FGSI (UFGSI)	Scoring system used to calculate risk of mortality in Fourniers gangrene	11 variables include: temperature, heart rate, respiratory rate, serum sodium, potassium and creatinine level, haematocrit, white blood cell count and serum bicarbonate, age and extent of gangrene With cut off of 9 for mortality AUC 0.947; 95% CI: 0.873–0.994 Score of 9 or less was associated with an 81% probability of survival ($p < 0.001$)	Uses the same parameters as FGSI but also takes into account extent of gangrene in score and age of patient	Shown to be more accurate than the FGSI in this study Specific to FG Highly accurate	Retrospective, single centre study Small study – 80 patients	Yes
Roghmann et al. 2012[85]	Age-adjusted Charlson comorbidity index (aCCI)	Scoring system used to estimate 10 year survival in patients	Takes into account the presence or absence of a wide range of co-morbidities, giving a 10-year survival rate. Increasing age reduces survival. Cut-off score used was $\geqslant 4$. AUC 0.819 (0.651–0.921)	Well validated globally	aCCI well validated globally Some prospective data collection Moderately accurate	Partly retrospective single centre study Small study – 44 patients Not specific to FG	Yes – but not for FG
Roghmann et al. 2012[85]	Surgical APGAR score (SAS)	Scoring system that predicts postoperative risk of major complication, including death.	Three variables: Estimated blood loss, lowest mean arterial pressure and lowest heart rate. Cut off score used was $\leqslant 4$ AUC 0.749 (0.571–0.881)	Well validated globally	SAS well validated globally Some prospective data collection	Partly retrospective single centre study Small study – 44 patients Not specific to FG	Yes – but not for FG
Lin et al. 2014[86]	Simplified FGSI (SFGSI)	Scoring system used to calculate risk of mortality in Fourniers gangrene	Only creatinine, hematocrit and potassium used to create a three-score index AUC 0.890 This simplified FGSI was shown to be non-inferior to FGSI in our this study. With a cut-off score of two, the sensitivity and specificity were 87% and 77%, respectively	Very short score	Only 3 parameters – easy and quick to use Specific to FG Highly accurate	Retrospective, single centre study Small study – 85 patients Patients from a 23-year period	Yes

(Continued)

Table 11. (Continued)

Author, year	Nomogram name	Description	Variables/Predictors	Unique features	Advantages	Drawbacks	External validation?
Erdogan et al. 2015[87]	NUMUNE Fournier score (NFS)	Scoring system used to calculate risk of mortality in Fourniers gangrene	Five variables included: age > 60 years, BUN > 40 mg/dL, RDW > 14.95 %, albumin level < 20 mg/dL and presence of sepsis With cut-off score of 2, AUC 0.957 (95% CI 0.908–1.0, $p < 0.000$)	–	Specific to FG Only 5 parameters, quick and easy to use Highly accurate	Retrospective, single centre study Small study – 84 patients	Yes
Bozkurt et al. 2015[88]	Laboratory Risk Indicator for Necrotizing Fasciitis (LRINEC)	Scoring system for necrotising soft tissue infections	Six variables include variables include: C-reactive protein, white blood cell count, haemoglobin, sodium, creatinine, glucose. Cut of score of six used as predictor of worse prognosis ($p < 0.05$)	–	Well validated in necrotising soft tissue infections No AUC calculations	Retrospective, single centre study Small study – 33 patients Not specific to FG	Yes – but not for FG
Çomçalı et al. 2022[48]	Fournier's Gangrene Mortality Prediction Model (FGMPM)		Variables included: heart rate, respiratory rate, blood albumin, urea level, neutrophil to leukocyte ratio, age, extent of gangrene, histological analysis of extent of gangrene and need for intensive care AUC for FGMPM found to be 0.995 (0.987–1.000)	Included histological analysis of gangrenous tissues	Shown to be more accurate than FGSI, UFGSI and ACCI Specific to FG	Retrospective, single centre study Larger study – 144 patients Requires histological analysis Multiple variables, difficult to calculate	No
Noegroho et al. 2023[89]	Quick Sepsis-related Organ Failure Assessment score (qSOFA)	Identifies high-risk patients for in-hospital mortality with suspected infection outside the ICU	Three variables include: blood pressure, respiratory rates, and the Glasgow Coma Scale (GCS). AUC 0.942	–	qSOFA well validated globally Strong positive correlation between qSOFA and FGSI Quick and easy to calculate and use	Retrospective, single centre study Small study – 67 patients Not specific to FG	Yes
Tazeoglu et al. 2023[90]	Temperature-neutrophils-multiple organ failure (TNM) scoring system	Scoring system for critically unwell patients	Three variables include: temperature, neutrophil count and presence of multiorgan failure Patients with TNM scores 3–4 had a 9.38 (95% CI, 3.01–29.28) times greater risk of exit than patients with scores 1–2	–	Quick and easy to calculate and use	Retrospective, single centre study Larger study – 167 patients	Yes – but not for FG

Externally validated tools are highlighted green.
AUC, area under the curve; FG, Fournier's Gangrene; FGSI, Fournier's gangrene severity index.

Table 12. Scoring systems and nomograms in epididymitis.

Author, year	Nomogram name	Description	Variables/ Predictors	Unique features	Advantages	Drawbacks	External validation?
Liu et al. 2023[92]	N/A	Diagnostic nomogram for differentiating epididymal tuberculosis (TB) from bacterial epididymitis	Body mass index, purified protein derivative, and chronic infection C-Index 0.98 (95% CI 0.94–1.01)	Highly specific to differentiation between TB and bacterial epididymitis	Highly accurate Specific to epididymitis	Retrospective study Small sample size – 147 Not clinically relevant for the majority of patients in developed countries	No

AUC, area under the curve.

patients with an AUC of 0.819 (0.651–0.921). The SAS is a scoring system consisting of three parameters used to calculate postoperative risk of death. In this study, it was shown to be less accurate than the aCCI, FGSI and UFGSI with an AUC of 0.749 (0.571–0.881). Overall, there was no significant difference between the performance of the scoring systems in this partly prospective study of 44 patients.

Another scoring system developed from the FGSI is the Simplified FGSI (SFGSI), developed by Lin et al.[86] In this study, the parameters in the FGSI were assessed and the variables haematocrit, creatinine and potassium were found to be statistically significant. When these variables were used, the AUC was found to be 0.890, and the simplified FGSI was found to be non-inferior to the FGSI. The score has been externally validated.

In 2015, Erdogan et al.[87] developed their score, the Numune Fournier score (NFS). The NFS consists of five variables, so is quick to calculate. With cut-off score of 2, the AUC was 0.957 (95% CI 0.908–1.0, $p < 0.000$) with a sensitivity of 95.1%, indicating excellent accuracy. The score has been externally validated, with this study finding accuracy with an AUC of 0.823.[91] Bozkurt et al.[88] assessed the Laboratory Risk Indicator for Necrotizing Fasciitis (LRINEC) score, a scoring system validated for use in necrotising soft tissue infections. They found that a cut-off score of six used as predictor of worse prognosis ($p < 0.05$); however, there was no AUC calculation done in this study and the LRINEC is not specific to Fournier's gangrene.

In 2022, Çomçalı et al.[48] developed, through logarithmic regression, the Fournier's Gangrene Mortality Prediction Model (FGMPM). They compared the strengths of the FGSI, UFGSI and aCCI and the newly developed model was reported to have high levels of accuracy, with an AUC of 0.995, more accurate than the FGSO, UFGSI and aCCI. This was with the largest cohort seen in the literature, of 144 patients. Of note, a variable in the score is that of histological analysis of the tissue, which would be extremely difficult to obtain given the rapid onset of the condition. Noegroho et al.[89] assessed the performance of the quick sepsis-related organ failure assessment score (qSOFA). This is a well-established score that is extremely quick and easy to calculate. It was shown to be highly accurate in FG patients with an AUC 0.942. It has been externally validated. Lastly, Tazeoglu et al., in 2023,[90] reported on the Temperature-Neutrophils-Multiple Organ Failure (TNM) scoring system in FG patients, a relatively new scoring system used to evaluate critically unwell patients. This score consists of three variables and as such, is very quick and easy to calculate. They found that patients with TNM scores 3–4 had a 9.38 (95% CI, 3.01–29.28) times greater risk of exit than patients with scores 1–2.

Epididymitis

Only one nomogram was identified for epididymitis, developed by Liu et al. in 2023,[92] this is shown in Table 12. This diagnostic nomogram was developed to differentiate epididymal tuberculosis (TB) from bacterial epididymitis. It was shown to be accurate with a C-index of 0.98.

Discussion

Given the subjective nature of PROMs, which can often involve complex topics, the development of an effective PROM is difficult and requires the acquisition of a large volume of qualitative data from relevant sources prior to development.[11] All items in a PROM should be relevant for the issue being assessed and the PROM should consider all concerns relevant to the patient, whilst concomitantly being understood by the patient.[12] Several guidelines concerning the development and evaluation of PROMs have been developed, including the consensus-based standards for the selection of health measurement instruments (COSMIN) guidelines,[12] which aim to ensure PROMs are effective tools for gathering such data. Concurrently, there have been concerns raised regarding diversity, inclusion and equity in PROMs, with calls to ensure that PROMs are developed by taking into account a range of populations and developed to be accessible and suitable for all patients.[15] In this atlas, we provide the first overview of the different PROMs used in UTIs and allied conditions. We have not carried out formal analysis of the available PROMs using a validated tool such as the COSMIN methodology, as this was felt to be beyond the scope of this article. This study is designed to provide a comprehensive overview of the literature, with the PROMS that can be utilised in UTI available in one place for the clinician managing patients with UTI.

PROMs have significant utility in the management of patients with UTI. As part of a general shift in medicine towards greater consideration of the impact of disease on patients' QoL, these allow an opportunity for clinicians to understand this effect. Most are easy for patients to complete and would be easily transferrable to a digital form for patients to complete on a smartphone whilst waiting for an appointment, for example. Further, specific to rUTI, there are now a plethora of available treatments ranging from conservative to intravesical therapies. By better understanding the effect of recurrent UTI on patients' QoL, this will allow clinicians to better empathise with patients and make decisions in partnership, perhaps with a view to initiating more, or less, invasive therapies depending on the severity of the rUTI on the patient's QoL. Following treatment of acute and recurrent UTI, the use of a validated PROM will allow clinicians to track the effect of this on the patient's QoL and symptoms in an objective manner.

There are a plethora of scoring systems and nomograms available to the modern-day clinician, it is vital that the tool that is used is suitable for the patient being treated. Scoring systems concerning urolithiasis and urosepsis were not included in this overview. There were no other scoring systems or PROMs identified in the literature regarding UTIs. We have seen in this review, the large number of scoring systems and nomograms available for patients with UTI. For less severe UTI, nomograms seem to take precedence. The use of nomograms to calculate the risk of ESBL positive UTI[56,60] gives a perfect example of the use of patient data to help predict the risk of MDR organisms, which is of great concern to modern medicine. Further, as there is often uncertainty in the diagnosis of UTI, nomograms can help to more accurately and confidently diagnose UTI. Li et al.[59] developed a highly accurate nomogram for predicting the risk of UTI in children under the age of 3, we hope that further accurate nomograms can be developed for the wider population. Scoring systems tended to be used for more severe UTI as they are typically used in prognostication, allowing clinicians to assess the severity of a UTI, which plays a crucial role in the management of patients. Alongside clinical judgement, the generation of an objective score as to the severity of a UTI better informs the clinician when deciding on level of management of patients, for example, early referral to intensive or critical care departments. Further, as can be the case in Fournier's gangrene, there can be a significant risk of mortality, which can be difficult to quantify. With the use of scoring systems, this helps the clinician not only in the management of the patient but also in prognostication, which is needed during discussions with the patient and their relatives. It is vital that the accuracy of these scoring systems is assessed and the systems externally validated. We have reported on the available nomograms and scoring systems being used in UTI, as well as their reported accuracy and whether they have been externally validated.

Future directions

With the ongoing incorporation of artificial intelligence (AI) into medicine, as well as the

ongoing digitisation, collection and analysis of health-related data, this provides fascinating and exciting opportunities to utilise PROMs. Work is being done to integrate PROMs into AI healthcare technologies, which hopes to ensure that outcomes important to patients are included in such technologies.[93] Another interesting avenue for collection of this data is that of social media-based surveys such as that carried out by Gonzalez et al. in 2022.[94] In an increasingly technological, online world, social media provides rapid access to patients, whilst in the comfort of their own environment, away from the healthcare setting. Further analysis of PROMs using structured guidelines such as COSMIN is vital to ensure that the available PROMs are effective tools for clinicians and researchers. Further, agreement in governing bodies as to which PROM, nomogram or scoring system is most appropriate for each type of UTI could ensure standardisation across clinicians.

Conclusion

PROMs are useful tools and have utility within the management of patients with UTIs. Scoring systems can help in prognostication and have been used predominantly in patients with more severe urinary infections. This atlas allows clinicians access to a single point of reference for the wide range of PROMs, scoring systems and nomograms used in the management of UTIs. It is the first study to do so. By reporting on the type of tool, presence of external validation and accuracy of these tools, this atlas will help clinicians decide on which tools will be most helpful to each specific patient. However, further clarity is needed as to which of these tools is most appropriate for each type of UTI as each of these offers their own respective advantages and disadvantages. Formal analysis of all PROMs used in UTI using guidance such as that of COSMIN was outside the scope of this review, but future work using such frameworks to further analyse each PROM will help to clarify which PROMs are most useful for each type of UTI. Lastly, the increasing use of PROMs in healthcare and the integration of these into AI healthcare technologies provides an important tool in ensuring that consideration of patient wellbeing is incorporated in such technologies, as well as providing an exciting avenue for future research.

Declarations

Ethics approval and consent to participate

Our study did not require an ethical board approval as it is a review article

Consent for publication

Not applicable.

Author contributions

Nicholas L. Harrison: Data curation; Formal analysis; Project administration; Writing – original draft.

Arthur W. Day: Conceptualization; Data curation; Writing – original draft.

Zafer Tandogdu: Conceptualization; Writing – review & editing.

Gernot Bonkat: Conceptualization; Writing – review & editing.

Bhaskar K. Somani: Conceptualization; Supervision; Writing – review & editing.

Acknowledgements

None.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

Competing interests

The authors declare that there is no conflict of interest.

Availability of data and materials

Not applicable.

ORCID iD

Bhaskar K Somani https://orcid.org/0000-0002-6248-6478

Supplemental material

Supplemental material for this article is available online.

References

1. Wagenlehner FME, Bjerklund Johansen TE, Cai T, et al. Epidemiology, definition and treatment of complicated urinary tract infections. *Nat Rev Urol* 2020; 17(10): 586–600.

2. Flores-Mireles AL, Walker JN, Caparon M, et al. Urinary tract infections: epidemiology, mechanisms of infection and treatment options. *Nat Rev Microbiol* 2015; 13(5): 269–284.
3. Foxman B. The epidemiology of urinary tract infection. *Nat Rev Urol* 2010; 7(12): 653–660.
4. Medina M and Castillo-Pino E. An introduction to the epidemiology and burden of urinary tract infections. *Ther Adv Urol* 2019; 11: 1756287219832172.
5. Garcia-Bustos V, Escrig AIR, López CC, et al. Prospective cohort study on hospitalised patients with suspected urinary tract infection and risk factors por multidrug resistance. *Sci Rep* 2021; 11(1): 11927.
6. Kodner CM and Thomas Gupton EK. Recurrent urinary tract infections in women: diagnosis and management. *Am Fam Physician* 2010; 82(6): 638–643.
7. McLellan LK and Hunstad DA. Urinary tract infection: pathogenesis and outlook. *Trends Mol Med* 2016; 22(11): 946–957.
8. Naber KG, Tirán-Saucedo J and Wagenlehner FME, RECAP group. Psychosocial burden of recurrent uncomplicated urinary tract infections. *GMS Infect Dis* 2022; 10: Doc01.
9. European Association of Urology. EAU guidelines on urological infections [Internet], https://uroweb.org/guidelines/urological-infections/chapter/citation-information (2023, accessed 5 November 2023).
10. Churruca K, Pomare C, Ellis LA, et al. Patient-reported outcome measures (PROMs): a review of generic and condition-specific measures and a discussion of trends and issues. *Health Expect* 2021; 24(4): 1015–1024.
11. Magasi S, Ryan G, Revicki D, et al. Content validity of patient-reported outcome measures: perspectives from a PROMIS meeting. *Qual Life Res* 2012; 21(5): 739–746.
12. Terwee CB, Prinsen CAC, Chiarotto A, et al. COSMIN methodology for evaluating the content validity of patient-reported outcome measures: a Delphi study. *Qual Life Res* 2018; 27(5): 1159–1170.
13. Weldring T and Smith SMS. Patient-reported outcomes (PROs) and patient-reported outcome measures (PROMs). *Health Serv Insights* 2013; 6: 61–68.
14. Black N. Patient reported outcome measures could help transform healthcare. *BMJ* 2013; 346: f167.
15. Calvert MJ, Cruz Rivera S, Retzer A, et al. Patient reported outcome assessment must be inclusive and equitable. *Nat Med* 2022; 28(6): 1120–1124.
16. Ellison JS, Williams M and Keeley FX. Patient-reported outcomes in nephrolithiasis: can we do better? *J Endourol* 2018; 32(1): 10–20.
17. Mehmi A, Jones P and Somani BK. Current status and role of patient-reported outcome measures (PROMs) in endourology. *Urology* 2021; 148: 26–31.
18. Brown G and Somani BK. Atlas of 35 patient reported outcome measures (PROMs) in andrology: a comprehensive overview of literature. *World J Urol* 2023; 41(2): 371–404.
19. Jackson MJ, N'Dow J and Pickard R. The importance of patient-reported outcome measures in reconstructive urology. *Curr Opin Urol* 2010; 20(6): 495–499.
20. Baradaran N, Hampson LA, Edwards TC, et al. Patient-reported outcome measures in urethral reconstruction. *Curr Urol Rep* 2018; 19(7): 48.
21. Cole AP, Koelker M, Makanjuola J, et al. Can PROMs improve racial equity in outcomes after prostatectomy? *Nat Rev Urol* 2023; 20(3): 125–126.
22. Dincer AN, Brunckhorst O, Genel O, et al. Quality of life, anxiety and depression patient-reported outcome measures in testicular cancer: a systematic review. *Psychooncology* 2021; 30(9): 1420–1429.
23. Ratti MM, Gandaglia G, Sisca ES, et al. A systematic review to evaluate patient-reported outcome measures (PROMs) for metastatic prostate cancer according to the consensus-based standard for the selection of health measurement instruments (COSMIN) methodology. *Cancers (Basel)* 2022; 14(20): 5120.
24. Mason SJ, Catto JWF, Downing A, et al. Evaluating patient-reported outcome measures (PROMs) for bladder cancer: a systematic review using the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) checklist. *BJU Int* 2018; 122(5): 760–773.
25. Piontek K, Donhauser T, Kann G, et al. Patient-reported outcome measures for uncomplicated urinary tract infections in women: a systematic review. *Qual Life Res* 2023; 32(8): 2137–2153.
26. Bermingham SL and Ashe JF. Systematic review of the impact of urinary tract infections

on health-related quality of life. *BJU Int* 2012; 110(11 Pt C): E830–E836.

27. Oprita B, Aignatoaie B and Gabor-Postole DA. Scores and scales used in emergency medicine. Practicability in toxicology. *J Med Life* 2014; 7 Spec No. 3(Spec Iss 3): 4–7.
28. Balachandran VP, Gonen M, Smith JJ, et al. Nomograms in oncology: more than meets the eye. *Lancet Oncol* 2015; 16(4): e173-80.
29. Challener DW, Prokop LJ and Abu-Saleh O. The proliferation of reports on clinical scoring systems: issues about uptake and clinical utility. *JAMA* 2019; 321(24): 2405–2406.
30. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021; 372: n71.
31. Wild DJ, Clayson DJ, Keating K, et al. Validation of a patient-administered questionnaire to measure the activity impairment experienced by women with uncomplicated urinary tract infection: the Activity Impairment Assessment (AIA). *Health Qual Life Outcomes* 2005; 3: 42.
32. Clayson D, Wild D, Doll H, et al. Validation of a patient-administered questionnaire to measure the severity and bothersomeness of lower urinary tract symptoms in uncomplicated urinary tract infection (UTI): the UTI Symptom Assessment questionnaire. *BJU Int* 2005; 96(3): 350–359.
33. Ernst EJ, Ernst ME, Hoehns JD, et al. Women's quality of life is decreased by acute cystitis and antibiotic adverse effects associated with treatment. *Health Qual Life Outcomes* 2005; 3: 45.
34. Maxwell CJ, Kang J, Walker JD, et al. Sex differences in the relative contribution of social and clinical factors to the Health Utilities Index Mark 2 measure of health-related quality of life in older home care clients. *Health Qual Life Outcomes* 2009; 7: 80.
35. Eriksson I, Gustafson Y, Fagerström L, et al. Do urinary tract infections affect morale among very old women? *Health Qual Life Outcomes* 2010; 8: 73.
36. Alidjanov JF, Abdufattaev UA, Makhsudov SA, et al. New self-reporting questionnaire to assess urinary tract infections and differential diagnosis: acute cystitis symptom score. *Urol Int* 2014; 92(2): 230–236.
37. Holm A, Cordoba G, Siersma V, et al. Development and validation of a condition-specific diary to measure severity, bothersomeness and impact on daily activities for patients with acute urinary tract infection in primary care. *Health Qual Life Outcomes* 2017; 15(1): 57.
38. Alanazi MQ. Evaluation of health-related quality of life in women with community-acquired urinary tract infections using the EQ-5D-3L in Saudi Arabia. *Patient Prefer Adherence* 2020; 14: 2419–2426.
39. Gágyor I, Rentzsch K, Strube-Plaschke S, et al. Psychometric properties of a self-assessment questionnaire concerning symptoms and impairment in urinary tract infections: the UTI-SIQ-8. *BMJ Open* 2021; 11(2): e043328.
40. Thompson J, Marijam A, Mitrani-Gold FS, et al. Activity impairment, health-related quality of life, productivity, and self-reported resource use and associated costs of uncomplicated urinary tract infection among women in the United States. *PLoS One* 2023; 18(2): e0277728.
41. Chang SJ, Lin CD, Hsieh CH, et al. Reliability and validity of a chinese version of urinary tract infection symptom assessment questionnaire. *Int Braz J Urol* 2015; 41(4): 729–738.
42. Renard J, Ballarini S, Mascarenhas T, et al. Recurrent lower urinary tract infections have a detrimental effect on patient quality of life: a prospective, observational study. *Infect Dis Ther* 2014; 4(1): 125–135.
43. Ennis SS, Guo H, Raman L, et al. Premenopausal women with recurrent urinary tract infections have lower quality of life. *Int J Urol* 2018; 25(7): 684–689.
44. Wagenlehner F, Wullt B, Ballarini S, et al. Social and economic burden of recurrent urinary tract infections and quality of life: a patient web-based study (GESPRIT). *Expert Rev Pharmacoecon Outcomes Res* 2018; 18(1): 107–117.
45. Croghan SM, Khan JSA, Jacob PT, et al. The recurrent urinary tract infection health and functional impact questionnaire (RUHFI-Q): design and feasibility assessment of a new evaluation scale. *Can J Urol* 2021; 28(3): 10729–10732.
46. Newlands AF, Roberts L, Maxwell K, et al. The recurrent urinary tract infection symptom scale: development and validation of a patient-reported outcome measure. *BJUI Compass* 2023; 4(3): 285–297.
47. Newlands AF, Roberts L, Maxwell K, et al. Development and psychometric validation of a patient-reported outcome measure of recurrent urinary tract infection impact: the Recurrent UTI Impact Questionnaire. *Qual Life Res* 2023; 32(6): 1745–1758.

48. Çomçalı B, Ceylan C, Altun Özdemir B, et al. Comparison of the newly developed Fournier's gangrene mortality prediction model with existing models. *Ulus Travma Acil Cerrahi Derg* 2022; 28(4): 490–497.

49. Koopman C, Pelletier KR, Murray JF, et al. Stanford presenteeism scale: health status and employee productivity. *J Occup Environ Med* 2002; 44(1): 14–20.

50. Kelleher CJ, Cardozo LD, Khullar V, et al. A new questionnaire to assess the quality of life of urinary incontinent women. *Br J Obstet Gynaecol* 1997; 104(12): 1374–1379.

51. Zuluaga L, Caicedo JI, Mogollón MP, et al. Anxiety and depression in association with lower urinary tract symptoms: results from the COBaLT study. *World J Urol* 2023; 41(5): 1381–1388.

52. Shaw C, Matthews RJ, Perry SI, et al. Validity and reliability of a questionnaire to measure the impact of lower urinary tract symptoms on quality of life: the Leicester Impact Scale. *Neurourol Urodyn* 2004; 23(3): 229–236.

53. Suijker J, Stoop M, Meij-de Vries A, et al. The impact of necrotizing soft tissue infections on the lives of survivors: a qualitative study. *Qual Life Res* 2023; 32(7): 2013–2224.

54. Hu JQ, Yu PC, Shi X, et al. Prognostic nomograms for predicting overall survival and cancer-specific survival of patients with major salivary gland mucoepidermoid carcinoma. *J Cancer* 2019; 10(18): 4380–4388.

55. Çorbacıoğlu ŞK and Aksel G. Receiver operating characteristic curve analysis in diagnostic accuracy studies: a guide to interpreting the area under the curve value. *Turk J Emerg Med* 2023; 23(4): 195–198.

56. García-Tello A, Gimbernat H, Redondo C, et al. Prediction of infection caused by extended-spectrum beta-lactamase-producing Enterobacteriaceae: development of a clinical decision-making nomogram. *Scand J Urol* 2018; 52(1): 70–75.

57. Ben Ayed H, Koubaa M, Hammami F, et al. Performance of an easy and simple new scoring model in predicting multidrug-resistant enterobacteriaceae in community-acquired urinary tract infections. *Open Forum Infect Dis* 2019; 6(4): ofz103.

58. Zhang L, Zhang F, Xu F, et al. Construction and evaluation of a sepsis risk prediction model for urinary tract infection. *Front Med (Lausanne)* 2021; 8: 671184.

59. Li SC, Chi H, Huang FY, et al. Building nomogram plots for predicting urinary tract infections in children less than three years of age. *J Microbiol Immunol Infect* 2023; 56(1): 111–119.

60. Lu J, Wang L, Wei Y, et al. Trends and risk factors of extended-spectrum beta-lactamase urinary tract infection in Chinese children: a nomogram is built and urologist should act in time. *Transl Pediatr* 2022; 11(6): 859–868.

61. Tang WY, Wang W, Yang JX, et al. Development and validation of a nomogram for urinary tract infection in geriatric patients with hip fracture: a retrospective study. *Eur Rev Med Pharmacol Sci* 2023; 27(22): 10884–10898.

62. Cai T, Mazzoli S, Migno S, et al. Development and validation of a nomogram predicting recurrence risk in women with symptomatic urinary tract infection. *Int J Urol* 2014; 21(9): 929–934.

63. van der Starre WE, Zunder SM, Vollaard AM, et al. Prognostic value of pro-adrenomedullin, procalcitonin and C-reactive protein in predicting outcome of febrile urinary tract infection. *Clin Microbiol Infect* 2014; 20(10): 1048–1054.

64. Lalueza A, Sanz-Trepiana L, Bermejo N, et al. Risk factors for bacteremia in urinary tract infections attended in the emergency department. *Intern Emerg Med* 2018; 13(1): 41–50.

65. Wang W, Xie P, Zhang J, et al. A risk prediction model of urinary tract infections for patients with neurogenic bladder. *Int J Neurosci* 2021; 131(1): 31–39.

66. Lu X, Jiang H, Wang D, et al. Early warning models to predict the 90-day urinary tract infection risk after radical cystectomy and urinary diversion for patients with bladder cancer. *Front Surg* 2021; 8: 782029.

67. Buzzi G, Antonello M, Scognamiglio F, et al. Predictors of urinary tract infection after lower gastrointestinal surgery. *Langenbecks Arch Surg* 2023; 408(1): 342.

68. Gonzales Favoreto M, Pereira Gregorio E, Averbeck MA, et al. Independent validation of a predictive nomogram for risk of reinfection in women with recurrent non-complicated urinary tract infections. *Ther Adv Urol* 2020; 12: 1756287220922423.

69. Li Y, Liu Y, Huang Y, et al. Development and validation of a user-friendly risk nomogram for the prediction of catheter-associated urinary tract infection in neuro-intensive care patients. *Intensive Crit Care Nurs* 2023; 74: 103329.

70. Wang F, Wang X, Shi Y, et al. Development of a risk nomogram predicting urinary tract infection in patients with indwelling urinary catheter after radical surgery for cervical cancer. *Prog Urol* 2023; 33(10): 492–502.
71. Kubota M, Kanno T, Nishiyama R, et al.[A Novel scoring system: predicting septic shock at diagnosis easily in acute complicated pyelonephritis patients]. *Nihon Hinyokika Gakkai Zasshi* 2016; 107(1): 21–27.
72. Valent AM, Peticca K, DiMatteo A, et al. Pyelonephritis in pregnancy: prediction of prolonged hospitalization and maternal morbidity using prognostic scoring systems. *Am J Perinatol* 2017; 34(12): 1212–1218.
73. Fang NW, Chiou YH, Chen YS, et al. Nomogram for diagnosing acute pyelonephritis in pediatric urinary tract infection. *Pediatr Neonatol* 2022; 63(4): 380–387.
74. Jain A, Manikandan R, Dorairajan LN, et al. Emphysematous pyelonephritis: does a standard management algorithm and a prognostic scoring model optimize patient outcomes? *Urol Ann* 2019; 11(4): 414–420.
75. Stojadinović MM, Milovanović DR and Gajić BS. Scoring system development and validation for initial treatment failure in suppurative kidney infections. *Surg Infect (Larchmt)* 2011; 12(2): 119–125.
76. Prakash J, Tamil Muthu M, Balaji AR, et al. A novel prognostic scoring system for emphysematous pyelonephritis. *J Urol Renal Dis* 2019; 04(12): 1170.
77. Krishnamoorthy S, Zumla A, Sekar H, et al. Prognostic scoring system and risk stratification in patients with emphysematous pyelonephritis: an 11-year prospective study at a tertiary referral centre. *BJU Int* 2021; 127(4): 418–427.
78. Trujillo-Santamaría H, Robles-Torres JI, Teoh JYC, et al. A novel mortality risk score for emphysematous pyelonephritis: a multicenter study of the Global Research in the Emphysematous Pyelonephritis group. *Curr Urol* 2024; 18: 55–60.
79. Bibi M, Chaker K, Ouanes Y, et al. Comparison of prognosis of five scoring systems in emphysematous pyelonephritis patients requiring intensive care. *Int Urol Nephrol* 2023; 55(12): 3045–3050.
80. Huang JJ and Tseng CC. Emphysematous pyelonephritis: clinicoradiological classification, management, prognosis, and pathogenesis. *Arch Intern Med* 2000; 160(6): 797–805.
81. Chawla A, Bhaskara SP, Taori R, et al. Evaluation of early scoring predictors for expedited care in patients with emphysematous pyelonephritis. *Ther Adv Urol* 2022; 14: 17562872221078772.
82. Chen YH, Hsieh MS, Hu SY, et al. Scoring systems to evaluate the mortality risk of patients with emphysematous cystitis: a retrospective observational study. *J Pers Med* 2023; 13(2): 318.
83. Laor E, Palmer LS, Tolia BM, et al. Outcome prediction in patients with Fournier's gangrene. *J Urol* 1995; 154(1): 89–92.
84. Yilmazlar T, Ozturk E, Ozguc H, et al. Fournier's gangrene: an analysis of 80 patients and a novel scoring system. *Tech Coloproctol* 2010; 14(3): 217–223.
85. Roghmann F, von Bodman C, Löppenberg B, et al. Is there a need for the Fournier's gangrene severity index? Comparison of scoring systems for outcome prediction in patients with Fournier's gangrene. *BJU Int* 2012; 110(9): 1359–1365.
86. Lin TY, Ou CH, Tzai TS, et al. Validation and simplification of Fournier's gangrene severity index. *Int J Urol* 2014; 21(7): 696–701.
87. Erdoğan A, Aydoğan I, Şenol K, et al. Simple scoring system for prediction of mortality in Fournier's gangrene. *Eur J Trauma Emerg Surg* 2016; 42(4): 513–518.
88. Bozkurt O, Sen V, Demir O, et al. Evaluation of the utility of different scoring systems (FGSI, LRINEC and NLR) in the management of Fournier's gangrene. *Int Urol Nephrol* 2015; 47(2): 243–248.
89. Noegroho BS, Adi K, Mustafa A, et al. The role of quick sepsis-related organ failure assessment score as simple scoring system to predict Fournier gangrene mortality and the correlation with Fournier's Gangrene Severity Index: analysis of 69 patients. *Asian J Urol* 2023; 10(2): 201–207.
90. Tazeoglu D, Benli S and Colak T. Temperature-neutrophils-multiple organ failure grading as a prognostic indicator in fournier gangrene. *Surg Infect (Larchmt)* 2023; 24(8): 749–754.
91. Azmi YA, Alkaff FF, Renaldo J, et al. Comparison of different scoring systems for predicting in-hospital mortality for patients with Fournier gangrene. *World J Urol* 2023; 41(10): 2751–2757.
92. Liu P, Cai G, Gu H, et al. Diagnostic nomogram to differentiate between epididymal tuberculosis and bacterial epididymitis. *Infection* 2023; 51(2): 447–454.

93. Cruz Rivera S, Liu X, Hughes SE, et al. Embedding patient-reported outcomes at the heart of artificial intelligence health-care technologies. *Lancet Digit Health* 2023; 5(3): e168–e173.

94. Gonzalez G, Vaculik K, Khalil C, et al. Using large-scale social media analytics to understand patient perspectives about urinary tract infections: thematic analysis. *J Med Internet Res* 2022; 24(1): e26781.

Appendix 1 – Search terms

"urinary tract infection" OR "UTI" OR "acute urinary tract infection" OR "uncomplicated lower urinary tract infection" OR "complicated urinary tract infection" OR "acute lower urinary tract infection" OR "recurrent urinary tract infection" OR "cystitis" OR "acute cystitis" OR "recurrent cystitis" OR "urinary symptom*" OR "upper urinary tract infection" OR "pyelonephritis" OR "prostatitis" OR "urethritis" OR "epididymitis" OR "epididymoorchitis" OR "epididymo-orchitis" OR "orchitis" OR "urosepsis" OR "fourniers gangrene" OR "emphysematous pyelonephritis" AND "Patient Reported Outcome Measures"[Mesh] OR "Quality of Life"[Mesh] OR "patient reported outcome measure*" OR "prom" OR "pro" OR "quality of life" OR "health index" OR "health indices" OR "scoring system*" OR "nomogram" OR "grading tool*"