Horizon scan of diagnostic technologies for urinary tract infections and antimicrobial resistance

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Date: September 2025 – revised March & June 2026

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How to cite this document

Garcia Gonzalez-Moral S, Ewedairo O, Oliver A, Elgey J, Trenchard D, Jahan A and Mkwashi. Horizon scan for diagnostic technologies for urinary tract infection and antimicrobial resistance. NIHR Innovation Observatory. September 2025. DOI: 10.6084/m9.figshare.30122851

Acknowledgements and disclaimers

This study/project is funded by the National Institute for Health and Care Research (NIHR) [NIHR IO/project reference HSRIC-2016-10009]. The views expressed are those of the author(s) and not necessarily those of the NIHR or the Department of Health and Social Care.

We would like to thank our stakeholders at NHS England who provided expertise and advice during the protocol development and all phases of this horizon scan including screening, data extraction and report writing. In particular we would like to thank Dr Kerrie Davies for providing clinical expertise at all stages of this project.

Special acknowledgment is extended to Katie Hay, NIHR IO Stakeholder Relationship Manager, for their invaluable support in managing the project's delivery.

Conflicts of interest

The authors of this report have no conflicts of interest to declare.

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Acronyms

ABR	Antibacterial resistance
ABR	Antibiotic resistance
AMR	Antimicrobial resistance
AST	Antibiotic sensitivity testing
mPCR	Multiplex polymerase chain reaction
P-AST	Pooled antibiotic sensitivity testing
RUO	Research use only
UPEC	Uropathogenic Escherichia coli
UTI	Urinary tract infection
POC	Point of care
TB	Tuberculosis
TRL	Technology Readiness Level
QA	Quality Assessment

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Key findings and implications

1. **Several UTI diagnostic technologies, such as Direct-to-PCR (D2P) or U-treat, are already highly mature,** classified as TRL 9 and market ready. This highlights that the challenge lies not in the availability of technologies but in their adoption and integration into clinical pathways
2. **Timely diagnosis is essential:** Several technologies had turnaround times of under an hour. Rapid diagnoses are critical to reduce unnecessary antibiotic use and improve patient outcomes.
3. **A diverse technology landscape:** We identified technologies covering a broad range of modalities (flow cytometry, DNA based extraction methods, machine learning/artificial intelligence methods, mass spectrometry, new assays, point of care (POC), biomarker based methods, lateral flow assays, standard methods, imaging, blood culture methods).
4. **Few Innovations at clinical stage of development:** Approximately 13% of technologies and 25% of methods were found at TRLs 6 to 8, suggesting that relatively few novel tools and methods are progressing through mid-stage development, raising concerns around the sustainability of medium-term innovation, where improvements may be incremental rather than transformative.
5. **Gaps in biomarker based and POC tools:** 25% of technologies corresponded with biomarker based and POC. The development of rapid, near-patient diagnostics is particularly important for UTIs to guide treatment decisions and improve early detection of resistant pathogens.
6. **Significant societal and economic burden:** The burden of UTI is substantial, resulting in 1.2 million NHS bed-days (2023-2024) and associated hospital admissions costing more than £604 million. This further highlights the need for rapid, cost-effective diagnostic technologies and further development for those aimed at high-risk populations. Few studies identified in this horizon scan involved patients with complicated or recurrent UTIs.

Abstract

Background

Antimicrobial resistance (AMR) is a significant threat to global health, causing an estimated 1.27 million worldwide deaths in 2019 and contributing to a further 5 million. The UK's *Confronting Antimicrobial Resistance 2024-2029* strategy highlights the need for new accessible and rapid diagnostics to achieve safe, targeted antimicrobial use. Urinary tract infections (UTIs) are the most common bacterial infection in primary care and the second most common reason for antibiotic prescription in England. Accurate diagnosis is necessary to avoid misuse or overuse leading to antibiotic resistance (ABR), however, traditional methods such as laboratory-based urine culture can be slow and lacking in sensitivity.

This report aims to identify and describe new and emerging diagnostic tests for the detection of UTIs and associated AMR. The findings are intended to inform healthcare decision makers and support the development, evaluation, and adoption of effective, rapid diagnostics within the UK health system.

Methods

We aimed to identify, select and prioritise diagnostic health technologies for UTI and AMR that were approximately between Technology Readiness Level (TRL) 4-9. Technologies were included if they targeted any population (paediatric and adults) and were evaluated for diagnostic accuracy and readiness for clinical use. Searches were conducted in bibliographic databases, regulatory sources, and clinical trial registries using a combination of key terms that included concepts around diagnostics, AMR and UTI. Eligible studies met inclusion criteria defined using the PICOS framework and excluded review articles, prognostic studies, and non-UK relevant technologies.

Screening was conducted in Rayyan with dual screening of 20% of records and discrepancies resolved by discussion before the remaining records were single screened. The same process was applied at full-text stage. Data were manually extracted into Excel using a structured spreadsheet covering diagnostic performance, clinical application, TRL and development stage, with quality assurance (QA) conducted on all records by a second reviewer. Data analyses included an overview of all included technologies and further subgroup analyses.

Results

We identified 2,308 records, of which 162 met the inclusion criteria after de-duplication and screening. These included 54 unique diagnostic products and 84 methods or procedures for UTI and associated AMR. Unique diagnostic products were understood as named devices or diagnostic solutions, while methods were defined as general techniques or approaches (such as diagnostic workflows and integration pipelines) to diagnosis that may use one or more named commercial products in a particular sequence or flow that rendered that method as innovative. Technologies were split into these two categories to support robust comparative analysis within the results. For clarification, technologies are referred here as an umbrella term that encompasses products and methods. When we refer to both we will use 'technologies' when we refer to one or the other, we will use the specific terms e.g. products or methods. Twelve different subgroups were generated from the final included records. These included: flow cytometry, DNA based extraction methods, machine learning/artificial intelligence methods, mass spectrometry, new assays, point of care (POC), biomarker-based methods, lateral flow assays, standard methods, imaging, blood culture methods, and others.

Biomarker-based methods	Technologies measuring host-response or pathogen-derived biological markers (e.g. proteins, cytokines, cellular markers). This subgroup includes: Emerging biomarkers not previously established in routine sepsis diagnostics. Established biomarkers evaluated in novel combinations. Established biomarkers applied in new diagnostic platforms or clinical settings. These were not restricted to entirely novel molecules.
Blood culture methods	Technologies that: Improve traditional blood culture workflows, or Operate downstream of blood culture bottles to accelerate pathogen identification or susceptibility testing. This subgroup refers to workflow and method enhancement, not merely the blood sample type.

DNA extraction methods	Technologies designed to improve nucleic acid isolation efficiency prior to amplification-based detection.
Flow cytometry	Technologies using cytometric analysis of immune cell markers or cellular activation states.
Lateral flow assays	Paper-based or strip-based immunoassays providing qualitative or semi-quantitative outputs.
Machine learning	Algorithmic models using clinical, laboratory, molecular, imaging, or physiological data inputs to support diagnosis, prognosis, or treatment decisions.
Mass spectrometry	Technologies using MALDI-TOF or related approaches for pathogen identification or antimicrobial susceptibility inference.
New assays	Novel analytical platforms that do not fall clearly within traditional PCR, lateral flow, blood culture, or mass spectrometry categories. These include microfluidic platforms, biosensors, multiplex immunoassays, and hybrid technologies.
New scoring systems	Novel clinical scoring tools or algorithmic scoring frameworks distinct from NEWS2, SOFA, or qSOFA.
Next-generation sequencing	Metagenomic or targeted sequencing approaches for pathogen detection or AMR gene identification.
PCR	Conventional or isothermal nucleic acid amplification-based diagnostics.
Point-of-care tests	Technologies explicitly designed for near-patient use outside central laboratory settings.

Of the 54 unique products, many have the capacity to detect both pathogens and susceptibility (n=22), and the majority were identified as being TRL 9 (n=45). Diagnostic accuracy data were available for 77 technologies, with turnaround times ranging from 30 seconds to over 48 hours. A total of seventeen technologies used biomarker based methods, with twenty-one unique biomarkers being identified. The biomarkers with the highest frequency were interleukin-8 (IL-8), neutrophil gelatinase-associated lipocalin (NGAL), IL-1β and calprotectin. Across UK Health Security Agency (UKHSA) priority pathogens, our scan identified 15 technologies which targeted *Acinetobacter species*, 86 targeting *Escherichia coli*, and 24 targeting *Staphylococcus*

aureus. Further subsets were identified for technologies involving high risk or specialist populations, such as those for complicated or recurrent UTIS, and technologies exclusively for use in paediatric patients.

Conclusions

Our horizon scan reveals a diverse landscape of UTI diagnostic technologies. While most of these technologies are already highly mature and market-ready, there are relatively few innovations at mid-stage development. About a quarter of the technologies in this scan (n=33) were biomarker-based or POC diagnostic tools, indicating a response to the significant unmet need for rapid, accurate, and portable testing platforms to reduce unnecessary antibiotic use and improve early detection of resistant pathogens. Without additional development of more disruptive approaches, such as genomic, multiplex, or AI-enhanced diagnostics, future improvements may be incremental.

Background

The Antimicrobial resistance challenge and UK policy context

Antimicrobial resistance (AMR) poses a major threat to public health, modern medicine, and the achievement of the Sustainable Development Goals, with antibiotic-resistant infections causing an estimated 1.27 million deaths worldwide in 2019 and contributing to a further 5 million deaths associated with AMR.[1] AMR arises when bacteria undergo genetic mutations or acquire resistance genes from other bacteria, enabling them to survive antibiotic treatment and spread through hosts via contact, especially in settings with poor sanitation and infection control. While AMR was less prominent during the 1960s–80s due to the continuous development of new antibiotics, innovation has since stalled. This is primarily due to the depletion of easily discoverable compounds and insufficient financial incentives for pharmaceutical companies. Consequently, many current antibiotics are based on decades-old chemical structures, and the emergence of multidrug- and extensively drug-resistant bacteria — such as tuberculosis (TB) strains now found in 100 countries — poses a growing global health threat.[2]

In response, the WHO developed the Bacterial Priority Pathogens List (BPPL) in 2017, which has been updated in 2024, to guide research and development investment in new antibacterials, prioritising 13 key antibiotic-resistant phenotypes in critical, high, and medium

tiers. The list also supports AMR surveillance, infection prevention and control (IPC), and policy guidance.[1] In 2025, and specifically focused on pathogens relevant to the UK, the UK Health Security Agency (UKHSA) published their Priority Pathogen Families Tool that identifies 24 viral and bacterial pathogen families with the greatest potential to cause epidemics or pandemics, guiding research investment in diagnostics, therapeutics, and vaccines. This tool evaluates pathogens based on transmission, disease severity, resistance, and current countermeasures, aiming to direct proactive development of diagnostics and treatments rather than predict outbreaks. It is designed for researchers, funders, and policymakers, the tool will inform UKHSA's internal programs and external collaborations and will be updated regularly to reflect emerging threats and scientific advances.[3]

The UK policy paper *'Confronting antimicrobial resistance 2024-2029'*, published in May 2024, outlines the commitment to reducing the burden and risks posed by the increase of AMR. In this policy new, accessible and rapid diagnostic testing is seen as essential to achieving safe, targeted antimicrobial use, supporting stewardship practices, and enabling data-informed decisions that reduce the emergence and spread of antimicrobial resistance.[4]

Antimicrobial resistance in urinary tract infections

Urinary tract infections (UTIs) are infections of the kidneys, bladder, or urethra, diagnosed by symptoms and bacteria in the urine. UTIs can be classified according to the location or organs affected: lower UTI is an infection of the bladder also known as cystitis; while upper UTI is an infection of the ureters and kidneys also known as pyelonephritis.[5] UTIs may be classified by the number of times with which the infections occur: recurrent UTI is when repeated episodes occur in a period of 6 to 12 months[5], while chronic UTI is a long term condition that may be caused by bacteria entering the bladder wall.[6] UTIs are often associated with catheter use in hospitalised patients. [5] UTIs can also be defined as uncomplicated or complicated when more underlying conditions interact and increase the likelihood of a treatment not working.[5]

UTIs are the most common bacterial infection seen in primary care and the second most common reason for antibiotic prescription in England,[7,8] with between 50% and 75% of women experiencing at least one episode in their lifetime.[8,9] When not managed adequately, UTIs can lead to recurrent infections, sepsis or death. Accurate diagnosis is crucial to prevent misuse or overuse, which can lead to antibiotic resistance (ABR) as pathogens become less susceptible to antibiotics commonly used for UTI treatment.[9] In the UK, first line antibiotics for lower UTI

include trimethoprim, nitrofurantoin, pivmecillinam and fosfomycin as a second choice.[10] Antibiotic resistant (ABR) UTIs (pose a significant economic burden on patients and healthcare systems.[9] A 2019 review of the global burden of AMR estimated that UTI is the fourth cause of global deaths of which a substantial proportion were directly attributable to resistance.[11]

Traditional diagnostic methods include laboratory-based urine culture that also include antimicrobial sensitivity testing (AST), but the lengthy processing time of up to three days is a significant limitation. Besides the time, urine culture methods present some limitations as the culture can come back as negative even when a UTI is present, especially in the case of ABR UTI, but also culture methods are limited in certain populations such as elderly patients that might present with long term bacterial colonisation.[7] Dipsticks are a rapid first-line test for screening possible UTIs, providing results within minutes. However, these tests are often inaccurate and lack AST information to guide treatment. Therefore, a culture is required when these tests are not recommended or when symptoms suggest a UTI not identified by the dipstick test.[7] Aligning with recent UK policy,[4] in order to fight against global AMR and reduce the burden of UTI for patients and healthcare systems, modern, more rapid, accurate and resistance-aware methods are needed that overcome the limitations of the current tests.

This project has been commissioned by the Horizon Scanning, Demand Signalling and Business Development team in the NHSE Innovation Research and Life Science Strategy Group to support the NHSE Antimicrobial Resistance Diagnostics Programme.

Aim

The aim of this report is to use horizon scanning methods for the generation of actionable insights on innovations in diagnostic technologies for UTIs, with a particular focus on supporting early infection detection and AMR management. This horizon scan will build upon and update the previous Innovation Observatory (IO) scan conducted in 2021 on the same topic.[12]

Objectives:

1. To identify and critically describe new and emerging diagnostic tests for the detection of UTIs and associated AMR.

Methods

A protocol was agreed ahead of project start between stakeholders and the IO. This protocol was not published.

Scope

This horizon scan aimed to identify and select diagnostic health technologies to enable their prioritisation for implementation in the NHS. The scope of this scan focussed in the transitional and imminent horizons, that is, technologies that were approximately between Technology Readiness Level (TRL) 4 and 9 or that were between 7 years to market and 'market ready'. The innovative aspects of these technologies covered either new biomarkers, new diagnostic procedures, new settings, portability or self-testing devices, the incorporation of machine learning or artificial intelligence (AI) components to facilitate the detection of pathogens, susceptibility to AMR or both. The technologies in scope for this horizon scan cover all populations from paediatric to older adults. In line with the TRLs and the horizons for this project we searched appropriate sources of information able to yield relevant signals of development which encompassed published studies, including experimental and controlled trials, as well as regulatory information from regulators from US, EU and UK, and clinical trial registers of ongoing or completed studies. The technologies included in this report may be of interest to clinical staff in primary or secondary clinical settings as well as industry, guidelines development organisations and policy and healthcare decision-makers.

Eligibility criteria

The technologies included in this horizon scan were identified through horizon scanning of published research articles, regulatory designations and clinical trial registers. They met the technology readiness criteria outlined above and had to be intended for UTI diagnosis or AMR detection.

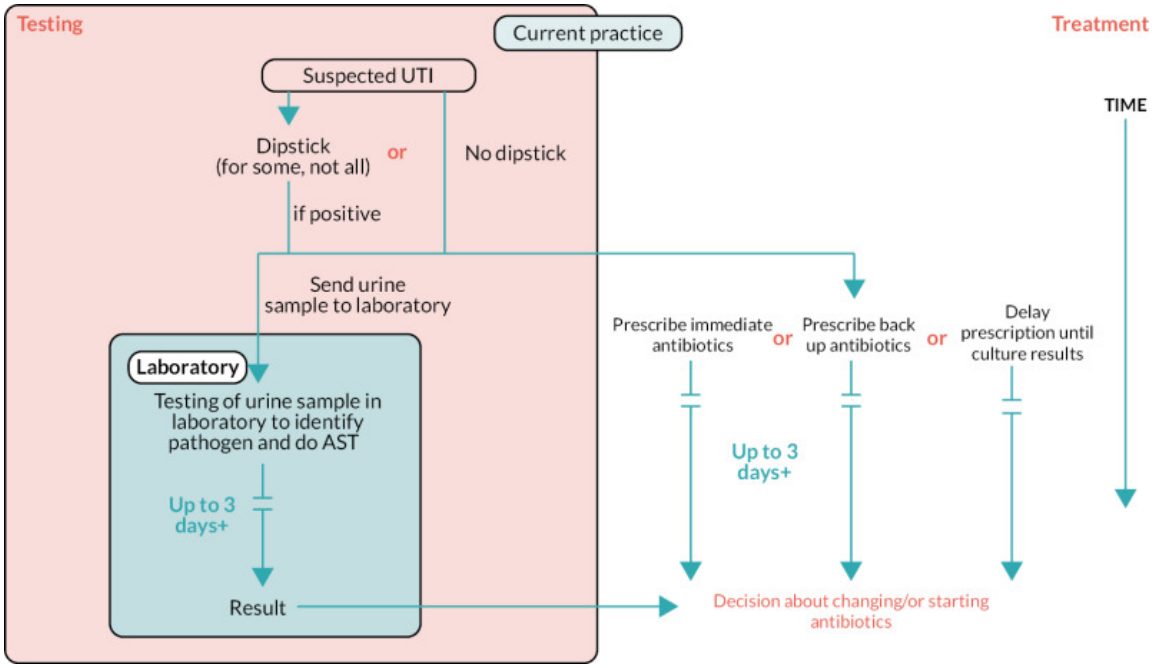
The inclusion criteria defined using the PICOS framework is as follows:

- **Population**: any (paediatric and adults)
- **Intervention**: any diagnostic technology aimed at identifying UTI or detecting AMR
- **Comparator**: could encompass another lab testing process, test or system or no comparator

- **Outcomes**: overview of the technology, including diagnostic accuracy, and if available, cost-effectiveness.

- **Setting**: all stages of the care pathway will be considered. The UTI pathway in UK is described in Figure 1 .

Figure 1. Urinary tract infection healthcare pathway



Source: *Tomlinson E, Ward M, Cooper C, James R, Stokes C, Begum S, Watson J, Hay AD, Jones HE, Thom H, Whiting P. Point-of-care tests for urinary tract infections to reduce antimicrobial resistance: a systematic review and conceptual economic model. Health Technol Assess. 2024 Nov;28(77):1-109. doi: 10.3310/PTMV8524. PMID: 39644102; PMCID: PMC11647557.*

We excluded review articles since these types of studies tend to take long to undertake and publish and would not usually include new and innovative technologies that present little to no effectiveness evidence. However, when reviews were identified through our searches, the technologies included in these were checked against our inclusion criteria and those in remit would be checked against our already included technologies to make sure that none were missed. We also excluded prognostic studies and prevalence and AMR screening studies that included technologies developed for detection of high prevalence pathogens in low- and middle-income countries in other continents such as Africa or South America which will not be generalisable in the UK.

Search strategy

Our searches covered the main bibliographic and non-bibliographic sources according to the technology readiness levels in scope. Our searches consisted of a combination of key words or search terms that included concepts around 'diagnostics', 'AMR' and 'UTI'. A prototype search was devised in Embase (Ovid). This search strategy was checked following the PRESS checklist[13] for accuracy and, once a final strategy was approved, it was translated to other bibliographic databases and, whenever appropriate, these were checked again for accuracy in translating the research question (full search strategies are included in Appendix A). For the non-bibliographic database search, we took a pragmatic approach and searched for concepts around AMR and UTI or UTI alone depending on the source. Further supplementary searches on Google by company or product name were undertaken to update the product information. These were undertaken ad hoc by horizon scanning analysts. The results from these searches were added to the data extraction for further analysis.

A detailed description of the sources searched, and the strategies used to retrieve signals of development in scope with this horizon scan are available in Appendix A.

Screening and Data collection

Following systematic searches across clinical trial registries and databases, results were de-duplicated in EndNote and screened in Rayyan. Initially, 20% of records were double screened (titles/abstracts) by all 5 reviewers (AJ, DT, AO, OE and JE) in a blinded manner, with discrepancies resolved by discussion. The remaining records were single-screened, and the same process was applied at full-text stage. An expert reviewer (SGGM) then confirmed study pertinence, and exclusion reasons were documented.

Data were extracted manually using a piloted Excel form (two papers per reviewer). Quality assurance (QA) was conducted by a second reviewer, with discrepancies resolved collaboratively. After piloting, records were divided equally among reviewers for full extraction, followed by a second QA to check hyperlinks, annotations, and accuracy against original sources.

Additional data collection updated TRLs, device names, and manufacturers to reflect changes in development stage or nomenclature in this rapidly evolving field.

Data extraction

For each identified technology, data were recorded on the device name, developer, and trial information (status, NCT number, locations, sponsors, and dates), as well as study design, indication, target population, setting, operator, country of development, regulatory status, and purpose. Technical details such as test type, pathogens detected, method, turnaround time, and performance data were extracted alongside any reported diagnostic accuracy measures (e.g., sensitivity, specificity, predictive values). Stage of development, including trial phase and TRL, was also documented. All information was captured in a structured Excel spreadsheet, with "Not reported (N/R)" entered where data were unavailable.

When TRLs were not reported, these were mapped to the technologies included using a standardised system to evaluate the maturity and development stage of new technologies (Table 1). The scale ranges from TRL 1, which represents the initial stage where a basic concept is established with a well-defined theoretical basis, to TRL 9, which indicates the highest level of readiness—where the technology has received regulatory approval or notification and is commercially available.

Table 1. Technology Readiness Levels (TRLs) used for mapping technology innovation

Technology readiness levels (TRLs)	**TRL 1:** Preliminary idea with well characterised theoretical case **TRL 2:** Principles are demonstrated through experimentation **TRL 3:** Early proof of concept demonstrated in the laboratory **TRL 4:** Late proof of concept demonstrated in real life conditions **TRL 5:** Technology refined and ready for initial human trials **TRL 6:** Technology has completed initial trials and demonstrates preliminary safety data **TRL 7:** Technology completes secondary trials and demonstrates further evidence for safety and efficacy **TRL 8**: Technology completes late-stage trials and has all evidence required to prove safety and efficacy **TRL 9:** Regulatory approval/notification takes place, product is made available to the market

Data analysis

The data analysis included an overview of all included studies and technologies, supported by a technology radar to illustrate maturity and spread. A summary table was developed to capture key characteristics such as device name, manufacturer, country of development, test type, and technology readiness level (TRL). Technologies were then analysed by TRL ranges (TRL 9; TRL 6–8; TRL 4–6), with a narrative summary describing the number and types of technologies within each range and whether they targeted pathogens, susceptibility, or both, supported by tables and bar charts. Additional analyses explored technologies by population focus, including gender, complicated and recurrent UTIs, and comorbidities, as well as the number and types of pathogens detected. For pathogens, the analysis also indicated whether they aligned with the UKHSA 2025 Pathogen Priority List, with results presented in both tables and visualisations such as bar or pie charts. Further analyses summarised biomarkers and antibiotics identified across all technologies, each presented with appropriate visualisations. Turnaround times (time to results) were compared across technologies, and settings of use were categorised by clinical context (e.g., primary care, hospital, or point of care) and as reported in the studies. Finally, test performance indicators (sensitivity, specificity, and AUC) were extracted for those technologies reporting such data, and visualised in a heatmap.

Data were extracted verbatim from the included papers and sources. Some level of standardisation was required in particular for device/test names and manufacturers. Quantitative data such as sensitivity and specificity percentages was extracted as reported. No further transformation of the data was undertaken.

Prioritisation and filtration

A formal risk of bias (RoB) assessment was not undertaken for the included studies. This decision reflects the scope of the horizon scan, which incorporated heterogeneous study types across different stages of technology development. Applying RoB tools only to studies with sufficient methodological detail would have disproportionately emphasized technologies supported by more extensive evidence bases, potentially biasing the results towards more established rather than innovative technologies.

The most relevant and important data points were identified in advance, in consultation with project stakeholders, during the protocol development stage. This ensured alignment between the data extraction process and the overall objectives of the horizon scan. The data fields were

pre-specified to capture information most pertinent to assessing the potential value, maturity, and applicability of the identified technologies. To maintain focus and analytical consistency, a filtration step was applied whereby information not corresponding to the agreed data points—such as tangential or redundant details—was excluded. This approach enabled us to concentrate on high-quality, pertinent information directly relevant to the project aims, while minimizing noise and ensuring comparability across heterogeneous sources.

We did not perform a GRADE-style assessment of certainty or confidence in the body of evidence. Given the scope of this horizon scan, which included diverse study types and technologies at varying stages of development, the application of formal certainty assessment frameworks such as GRADE was not appropriate. The purpose of the exercise was to provide an overview of emerging technologies rather than to synthesize or rate the strength of outcome evidence.

Expert or public engagement

We engaged with subject-matter experts at several stages of the project. At the protocol development stage, experts advised on key aspects such as the most relevant keywords and pathogens to include in the search strategies. They also provided input on the population, settings, and clinical pathways most pertinent to urinary tract infections (UTIs) in the UK. Throughout the project, experts were consulted at predefined stages, allowing them to comment on the types of records and technologies identified as well as their classification. Members of the public were not involved or consulted in this project.

Quality assurance

Quality assurance (QA) was embedded throughout the horizon scanning process to ensure rigour and consistency. QA checks were conducted at multiple stages, including during the development of the search strategy, title and abstract screening, full-text screening, and through double-checking of all data extracted from the final included studies. In addition, an independent expert review was applied to a 10% random sample at both the screening stages and following full data extraction, providing an additional layer of validation and reducing the risk of error or bias.

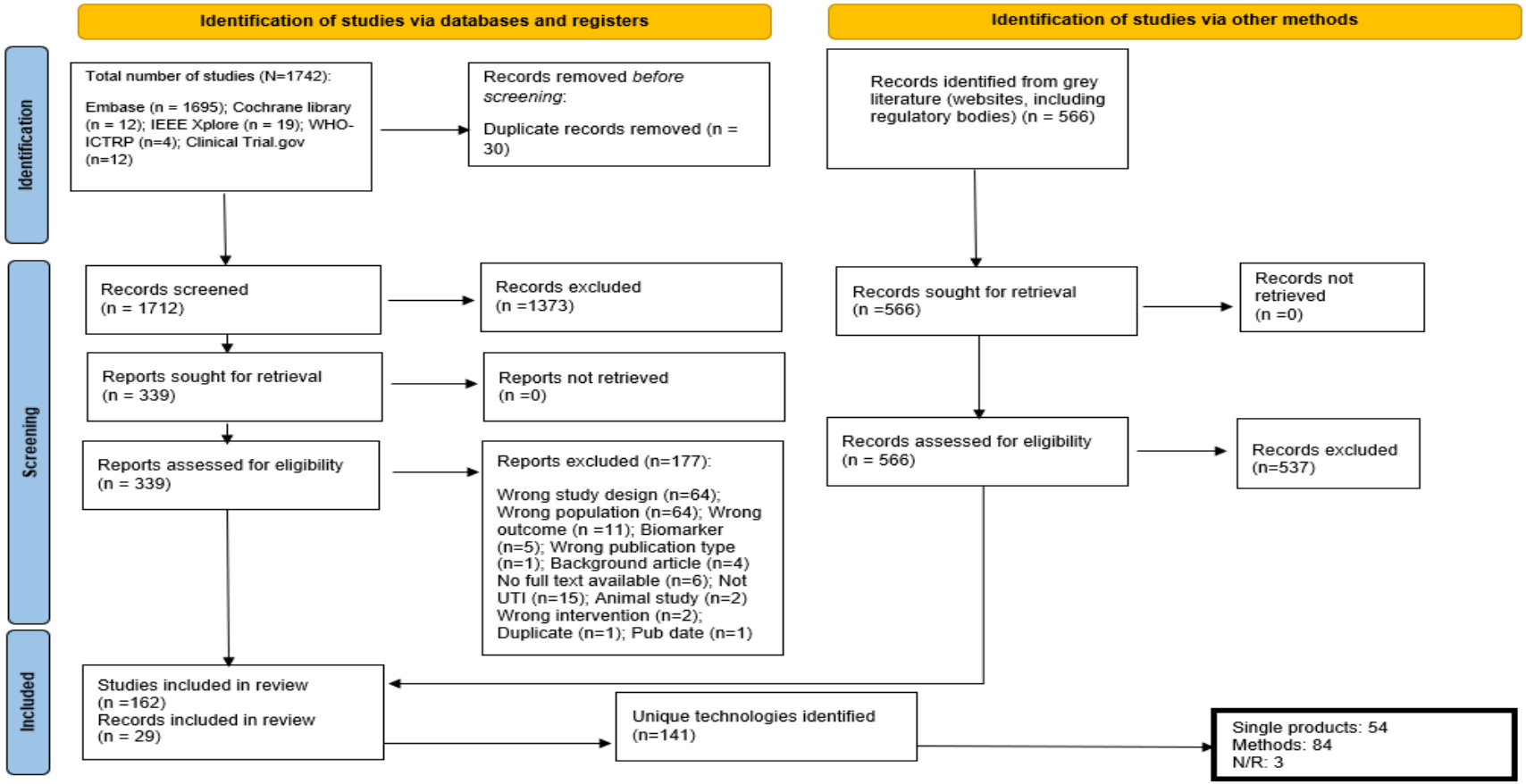
Results

Our horizon scanning searches identified a total of 2,308 records from databases and registers (n=1,742) and other sources such as regulatory and health technology assessment agencies (n=566). After de-duplication and screening title and abstracts, 806 records (339 and 566 respectively) meet the inclusion criteria and were screened for inclusion at full text. From that step a total of 162 records, including bibliographic and clinical trial protocols, were eligible for data extraction in addition to 29 reports from regulatory bodies. A further de-duplication stage between these two types of data sources was applied. The combined total of these two types of data yielded 162 records which collected data from all sources. Following we extracted the data relative to technologies reported in those records. This data extraction resulted in 54 unique products, understood as named devices or diagnostic solutions, and 84 different methods and procedures. Methods, in this context, were defined as general techniques or approaches to diagnosis that may use one or more named commercial products in a particular sequence or flow that rendered that method as innovative. For clarification, technologies are referred here as an umbrella term that encompasses products and methods. When we refer to both we will use 'technologies' when we refer to one or the other we will use the specific terms e.g. products or methods. Figure 2 presents an adapted PRISMA flowchart[14] for the identification and selection of records.

Single source of information characteristics

The technologies (products and methods) identified in this horizon scan were extracted from the 162 included studies and 29 records. These were collected from a varied range of sources including published literature, clinical trial protocols, HTA reports, NICE technology appraisals, MedTech news sites and regulatory bodies. Different signals were collected from different sources, for example, while regulatory bodies may provide brief information about a device name and manufacturer that has received an approval (and this was treated as a record), these data complemented the test performance and research findings from the included research studies. Signals emerging from records and studies were incorporated into a complete dataset of information on the agreed datapoints.

Figure 2. PRISMA flow diagram for study selection



Source: Page MJ, et al. BMJ 2021;372:n71. doi: 10.1136/bmj.n71.

Technology characteristics

Twelve different topic subgroups were generated from the final included records. These subgroups were generated from the available information on the intervention description and its intended purpose as reported in the studies. Broadly, these subgroups were Flow cytometry, DNA based extraction methods, Machine Learning/Artificial Intelligence methods, Others, Mass spectrometry, New assays, Point of Care (POC), Biomarker based methods, Lateral flow assays, Standard methods, Imaging and Blood culture methods. TRLs were mapped to a total of 161 records plus one remaining record not providing sufficient information for the mapping of suitable TRLs. It is worth noting that at this point more than one record could map to the same technology product. An analysis based on single technologies or methods, and not studies, is included in the following sections.

Figure 3. Technology radar of products by TRL and diagnostic group category

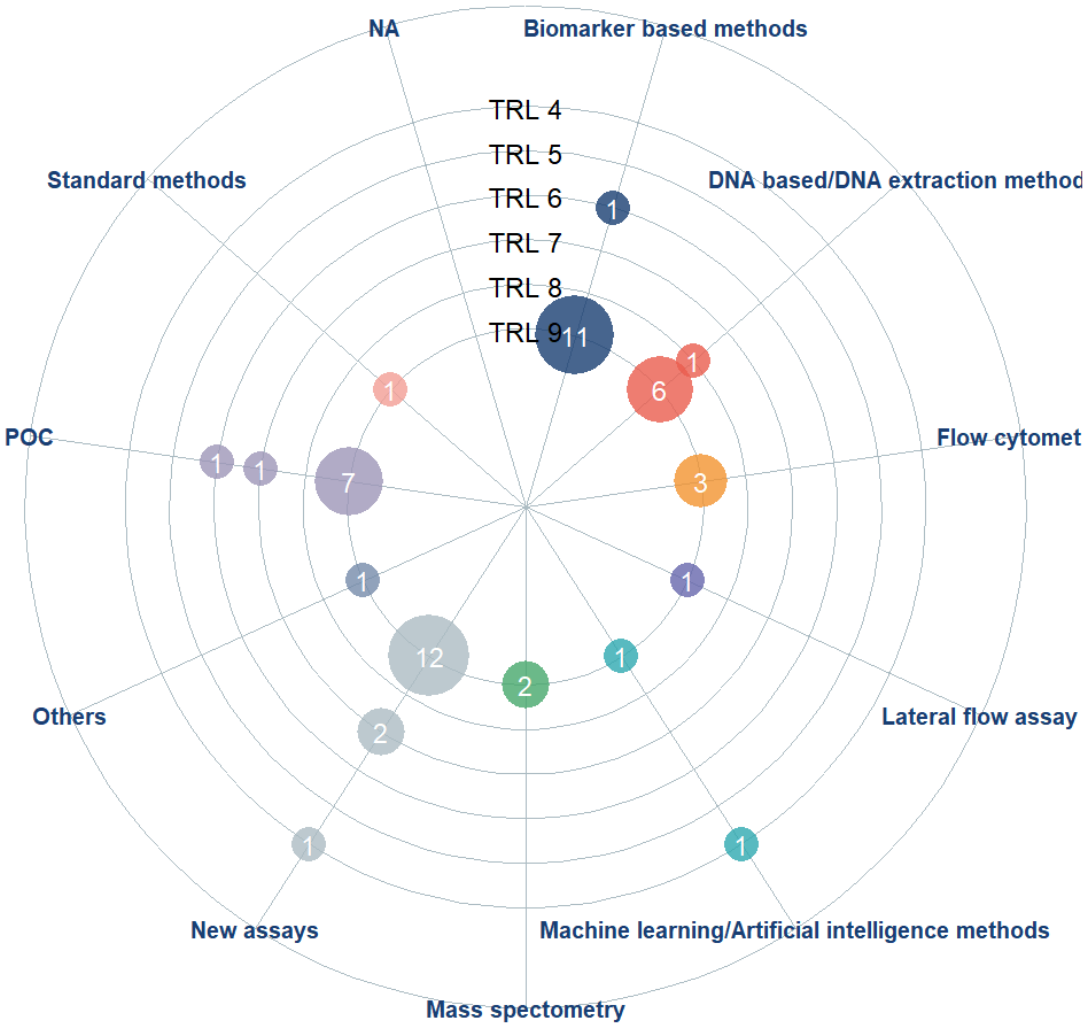
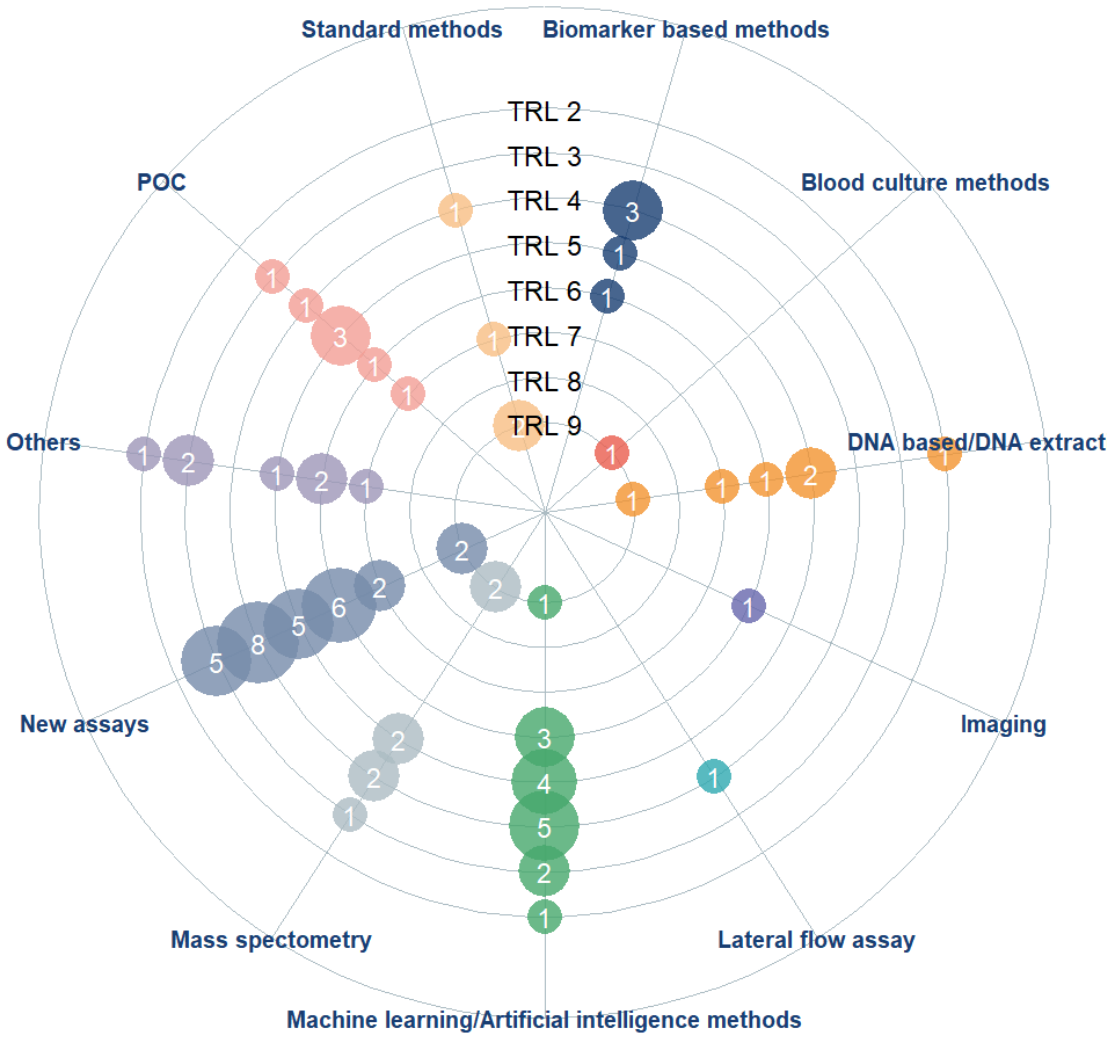


Figure 4. Technology radar of methods by TRL and diagnostic group category



Overview of identified products

A total of 54 unique products were identified. These were at different development stages and of different test categories. Table 2 presents the manufacturer and country of origin organised by TRL and subgroup of the products identified These products are designed for use in a number of settings including hospitals, laboratories and medical centres. The majority of them are designed for hospital or laboratory settings (n=34), with one product, the U-treat validated in UK-based medical centres. Another product (Human Lipocalin-2 / NGAL Quantikine ELISA Kit, human IL-8 / CXCL8 Quantikine ELISA Kit, human IL-1β / IL-1F2 Quantikine ELISA kit; Pathnostics) is intended for use in clinics. A total of seven (two potential) technologies were

designed for POC. The settings of use were not identified for 12 technologies as they were not reported by the studies they were identified from.

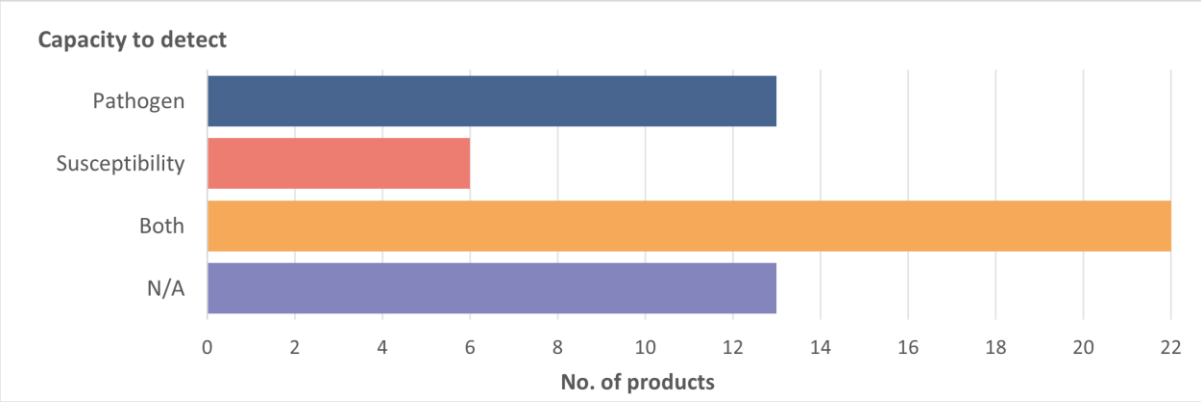
Table 2. Characteristics of included products (proprietary device names)

Product name (Developer)	Country of development
Technology Readiness Level 9	
Acuitas AMR gene panel (OpGen)	USA
BIOTIA-DX (Biotia Inc.)	USA
BIOTIA-ID Urine (Biotia Inc.)	USA
CHROMagar (Becton Dickinson)	USA
D3 ArrayTM-UTI (PathogenDx)	USA
Direct-to-PCR (D2P) (Scienetix)	USA
DocLab UTM 2.0 (Doc Lab Inc.)	USA
E-Test strips (bioMerieux)	France
GeneCapture (GeneCapture Inc.)	USA
Guidance UTI (Pathnostics)	USA
Human IL 17 ELISA Kit (Sigma Aldrich)	USA
Human Lipocalin-2 / NGAL Quantikine ELISA Kit, human IL-8 / CXCL8 Quantikine ELISA Kit, human IL-1β / IL-1F2 Quantikine ELISA kit; (Pathnostics)	USA
Human Lipocalin-2/NGAL ELISA Kit (R&D Systems)	Japan
Human sTLR4 ELISA Kit, Human sTLR5 ELISA Kit (BT Lab Biotech Co), Human IL-8 Platinum ELISA Kit (Bender MedSystems GmbH Campus)	Turkey
iFAST (impedance-based fast antimicrobial susceptibility test) (iFAST Diagnostics)	UK
Illumina NextSeq 550 (Illumina)	USA
LEGENDplex Human Inflammation Panel 1, BioLegend-HU Th Cytokine Panels (BioLegend)	USA
Lodestar DX (Llusern Scientific Limited)	UK
MALDI Biotyper (Bruker Daltonics)	Egypt
MALDI Biotyper MS ASTRA (Bruker Daltonics)	Germany
MBT STAR-Cepha kit (Bruker Daltonics)	Germany
MinION Mk1C in R9.4.1 flow cells (Oxford Nanopore Technologies)	UK
MinION sequencing system with Flongle flow cell (Oxford Nanopore Technologies)	UK
MultiPath analyzer (First Light Diagnostics)	USA

MUS-3600 full-automatic urine analyser (Dirui FUS-360 + H-1600) (Dirui Industrial Co., Ltd)	China
NANOPLEX (FluoretiQ)	UK
NextSeq550, Explify Urinary ID/AMR Panel (UPIP) (Illumina)	USA
Oxford Nanopore MK1c with Resistance-Associated Sequence Elements (RASE) pipeline (Oxford Nanopore Technologies)	UK
PA-100 AST System (Sysmex)	UK
PATHFAST Immunoanalyzer Presepsin Kit (PATHFAST)	Japan
PGE2 ELISA (Enzo Life Sciences)	USA
PhiCal® Calprotectin (Immundiagnostik AG)	Germany
Piezoelectric electronic noses (Sensorika–Novye Technologii)	Russia
Quantum Blue sCal, Quantum Blue reader (BÜHLMANN Laboratories AG)	Switzerland
Siemens Dimension (Siemens Healthineers AG.), Sysmex XN-1000 (Sysmex Corporation)	Germany Japan
sTREM-1 assay- ELISA (SunRed Biotechnology Co., Ltd)	China
Sysmex Automated Urine Analyzer (Sysmex Corporation)	Japan
Sysmex UF-5000 (Sysmex Corporation)	Japan
U-AST kit (Urinary tract infection–Antibiotic-sensitivity test kit) (Central Salt & Marine Chemicals Research Institute)	India
UriSed 3 Pro (77 Elektronika Kft)	Hungary
Uro-Quick system (Alifax S.r.l.), Vitek-MS system (bioMerieux)	Italy; France
U-treat (Test&Treat Ltd)	UK
VITEK 2 system (bioMérieux)	France
VITEK2 Compact (bioMérieux)	France
Vivalytic system (Bosch Healthcare Solutions GmbH)	Germany
Technology Readiness Level 8	
QuantStudio™ 12K Flex (Thermo Fisher Scientific)	USA
RapidPlate (MicroplateDX)	Scotland
Technology Readiness Level 7	
ColiSeq (Pathogen and Microbiome Institute, Northern Arizona University)	USA
DETECT (BioAmp Diagnostics, Inc.)	USA
Multiplex High Resolution Melting Assay (MHRM) (Applied Biosystems)	Iran
Technology Readiness Level 6	
Bactospin (BactoSpin Ltd)	Israel
USENSE platform (Welch Foundation)	USA
Technology Readiness Level 4	
DigiTOF (BiosparQ BV)	Netherlands
LVSi-RD (Biodesign Center for Bioelectronics and Biosensors, Arizona State University)	USA

From the 54 unique products, the majority had the capacity to detect both pathogens and susceptibility (n=22). This demonstrates a focus given to integrated diagnostic technologies for UTIs. Thirteen technologies had the capacity to detect pathogens and six focused exclusively on susceptibility. Technologies were included in the 'not applicable' (N/A) category (n=13) if they did not directly detect pathogens, susceptibility or both (for example those that detect specific biomarkers, Figure 5).

Figure 5. Antibiotic susceptibility and pathogen detection of included products



A total of 84 methods were identified. These were defined as technologies which were not distinct, named commercial products and instead were general techniques or approaches to diagnosis. Nine of the methods identified were mapped as TRL 9, with the remaining 75 methods identified as TRL 7 (n=6), TRL 6 (n=15), TRL 5 (n=18), TRL 4 (n=21), TRL 3 (n=11), TRL 2 (n=3), or N/A (n=1).

Table 3. Characteristics of included methods

Method (Developer)	Country of Development
Technology Readiness Level 9	
56-panel PCR test, NGS test	N/R
Expanded Quantitative Urine Culture (Loyola University)	USA
MALDI; 16S rRNA sequencing; WGS; UTI chromogenic agar; API 20E (BioMerieux; Illumina; Oxford Nanopore Technologies)	UK/EU
MALDI-TOF MS + lateral flow immunochromatography (Bruker Daltonics)	Egypt
MALDI-TOF MS rapid AST (Bruker Daltonics)	Egypt
Metagenomic next-generation sequencing (mNGS) (Henan Province People's Hospital)	China
PCR (Dicentra)	USA
Urine culture	N/R
Urine dipstick	N/R
Technology Readiness Level 7	
iPRISM (Technion Israeli Institute of Technology)	Israel
Metagenomics nanopore sequencing	N/R
mPCR + P-AST	N/R
Rapid phenotypic UTI AST (Apparecchiature Scientifiche Innovative)	Italy
Targeted next-generation sequencing (tNGS) urine panel (Guangzhou DaAn Clinical Laboratory Center Co. Ltd)	China
Urinary infection decision support tool	N/R
Technology Readiness Level 6	
CRP and Systemic immune-inflammation index (Dr. Sami Ulus Training and Research Hospital)	Turkey
Customised LAMP panel	N/R
Dynamic Surface-Enhanced Raman Spectroscopy	N/R
Engineered reporter phages	N/R
Fluorescent distance-based paper device (qLAMP)	N/R
Fourier-transform infrared (FTIR) spectroscopy	N/R
Holographic lens free imaging (Department of Biomedical Engineering, Johns Hopkins University)	USA

LCD platform- "Loop-mediated isothermal amplification (LAMP) and a centrifugal disk system" (Fosun Diagnostics Co., Ltd.)	China
LC-SRM-ML workflow	N/R
Machine learning prediction model (Ajou University)	South Korea
Machine learning-based diagnostic framework (University of Technology Sydney)	Australia
PANTOMIM (Plasmonic Array Nanohole Technology on Metal-Insulator-Metal (Imperial College London)	UK
Point-of-care phenotypic AST (GeneCapture Inc.)	USA
Reporter phage-based bioluminescence assay	N/R
UTI high-throughput multiplex genetic detection system (UTI-HMGS)	N/R
Technology Readiness Level 5	
Raman spectroscopy	N/R
16S ribosomal RNA gene sequencing (Jeju National University)	South Korea
EHR-based antibiotic resistance prediction model	N/R
Fluorescent distance-based paper device (LAMP)	N/R
Fluorescently labelled enterocin K1 flow cytometry assay (Norwegian University of Life Sciences)	Norway
Herringbone microfluidic chip + MALDI-TOF MS	N/R
IoT-Enhanced Machine Learning System for UTI Detection (Galgotias University, IILM University, JC Bose University of Science & Technology)	India
MALDI-TOF MS-based algorithm profiling coupled with Fc-MBL@Fe_3O_4 magnetic enrichment (Ningbo University)	China
Nicolet-i10 Fourier transform infrared (FITR) spectroscopy with Random Forest classifier (Ben-Gurion University of the Negev, Afeka Tel-Aviv Academic College of Engineering, Shamoon College of Engineering)	Israel
Off-the-shelf gas sensor array	N/R
Optical - KNeighborsClassifier algorithm (Medical University of Gdansk)	Poland
Optoplasmonic biosensor with metal nanotwin-embedded surfaces (Indian Institute of Technology)	India
Prussian Blue-based urine bacteria sensor	N/R
Pseudomonas aeruginosa-specific capture assay	N/R
Serum procalcitonin (PCT) assay	N/R
SlipChip	N/R
Smartphone-compatible dip-and-test microfluidic device (University of Reading)	UK

Universal Microbial Internal Transcribed Spacer (ITS) Identification System (University of Michigan)	USA
Technology Readiness Level 4	
2D-gel electrophoresis combined with LC-MS/MS (King Abdulaziz University)	Saudi Arabia
ANTIBIOLOG	N/R
CD-TEAA (NMPA Key Laboratory for Research and Evaluation of Drug Metabolism)	China
Disposable fibre-optic plasmonic sensor	N/R
Dual fluorescence turn-on sensor array (State Key Laboratory of Natural Medicines)	China
Electrochemical Lab-on-a-Chip (LOC) with resazurin bulk-modified screen-printed electrodes and antibiotic-loaded hydrogels (Manchester Metropolitan University)	UK
Electro fluidic capacitor-based biosensor for prostaglandin E2 detection (University of Texas)	USA
Integrated wearable fluorescence sensor (Department of Biomedical Engineering, Texas)	USA
Machine learning AMR prediction model	N/R
Machine-learning Decision Support (University of Oxford)	UK
Multiplex real-time fluorescence PCR (Clemson University)	USA
Nano electrokinetic paper-based analytic device (NEK-PAD) as a sample module of a Rapid and Accurate Nano electrokinetic Diagnostic System (RANDx) (Seoul National University)	South Korea
Negative urinalysis (Department of Urology, Glickman Urological and Kidney Institute)	USA
PDMS-BP@MoS_2 hydrophilic-hydrophobic SERS substrate (The First Affiliated Hospital of Ningbo University)	China
Prediction model for early detection of drug-specific resistance (IRCCS Istituto Giannina Gaslini)	Italy
qPCR	N/R
Rapid immunochromatographic test for Escherichia coli detection (Universidad de la República)	Uruguay
Resazurin bulk modified screen-printed macroelectrodes (R-SPEs) (Manchester Metropolitan University)	UK
SERS-active gold-coated PVDF membrane filter with handheld Raman spectrometer (Imperial College London)	UK

S-nitroso-N-acetyl penicillamine (SNAP)-impregnated silicone urinary catheter for colorimetric indole/E. coli detection (Virginia Commonwealth University)	USA
TensorFlow's Keras API (CNN) (Dayananda Sagar College of Engineering)	India
Technology Readiness Level 3	
"Turnon" terbium (Tb3+) photoluminescence assay supported on a paper-based platform (Indian Institute of Science)	India
A 3D-printed multichannel disposable cassette on a resonator (Microbial Pulse Diagnostics)	USA
AI-stimulated Raman scattering metabolic imaging system (Beijing Advanced Innovation Center for Biomedical Engineering)	China
Aluminium foil integrated with pegylated AuNP SERS (Department of Chemistry, Chaudhary Charan Singh University)	India
Compound Raman microscopy (Beijing Advanced Innovation Center for Biomedical Engineering)	China
Foley Catheter Insert (University of Maryland)	USA
GC-MS/MOS system (solid-phase microextraction-gas chromatography-mass spectrometry/metal oxide sensor system) (University of the West of England)	UK
Machine learning algorithm (Department of Urology, Glickman Urological and Kidney Institute, Cleveland Clinic Foundation)	USA
Predictive model from Lasso method and cytokine levels (Department of Nursing, The First Affiliated Hospital of Nanchang University)	China
SERS nanowire chip + machine learning classification platform (Indian Institute of Technology Delhi)	India
Surface-enhanced Raman scattering (SERS) and deep learning identification model	N/R
Technology Readiness Level 2	
Electrochemiluminescence biosensor (ECL signal measured of the MPI-E electrochemiluminescence analyser) (Institute for Advanced Interdisciplinary Research(iAIR), University of Jinan)	China
Hyperspectral imagining and random forest (HSI-RF) (Xi'an Institute of Optics and Precision Mechanics)	China
MSP-based biosensor (Materials Research and Education Center, Auburn University)	USA

Technology Readiness Level N/A	
MALDI-TOF with sonicated urine samples	

Three of the included records did not report the name of the technology used and therefore these have been excluded from the table above.

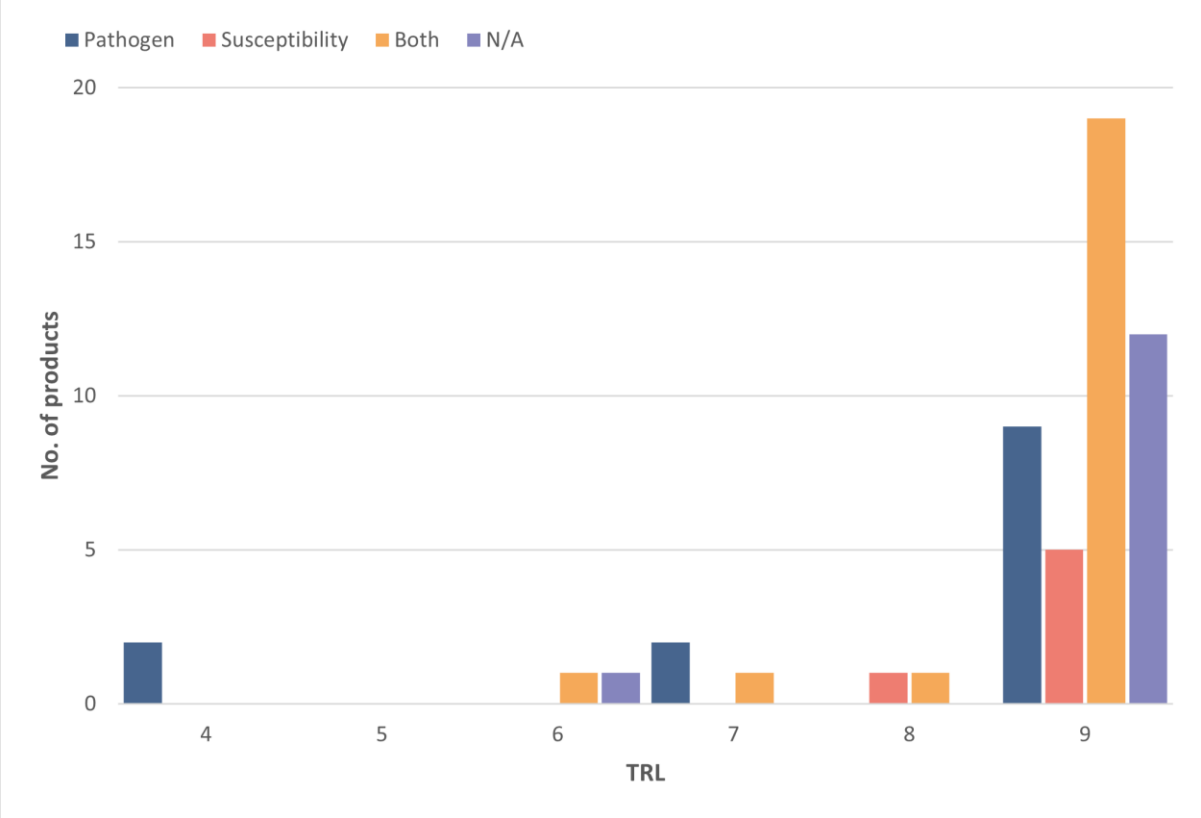
Technology Readiness Levels (TRLs)

The majority of products were identified as being TRL 9 (n=45). Of these, nine were able to identify pathogens, five identified susceptibility and nineteen were able to identify both pathogens and susceptibility (Figure 6). Eleven technologies were classified as using biomarker based methods, and seven were classified as being POC.

Only two products were identified as TRL 8 (the QuantStudio™ 12K Flex and the RapidPlate). Three products were identified as TRL 7 (the ColiSeq, the Multiplex High Resolution Melting Assay and DETECT). Of these, two were able to identify pathogens (the ColiSeq and the Multiplex High Resolution Melting Assay), one was able to identify susceptibility (the QuantStudio™ 12K Flex) and two were able to identify both pathogens and susceptibility (the RapidPlate and DETECT).

Two products were mapped as being TRL 6 and another two as TRL 4. Of these, two were able to identify pathogens (the DigiTOF and Large Volume Solution Scattering Imaging- Rapid Detection) and one identified both pathogens and susceptibility (the BactoSpin). No technologies were identified at TRL 5.

Figure 6. Technology Readiness Levels of included products distributed by ability to detect pathogens or AMR susceptibility



The majority of methods were identified as being TRL 5 (n=18). Of these, 13 were able to identify pathogens, two identify susceptibility and one both pathogens and susceptibility, while two technologies were categorised as N/A (Figure 7). Five of these were identified as new assays, and four were identified as using machine learning/AI methods, with the remaining TRL 5 methods classified into either POC (n=3), DNA based/DNA extraction methods (n=2), mass spectrometry (n=2), biomarker based methods (n=1), or other methods (n=1).

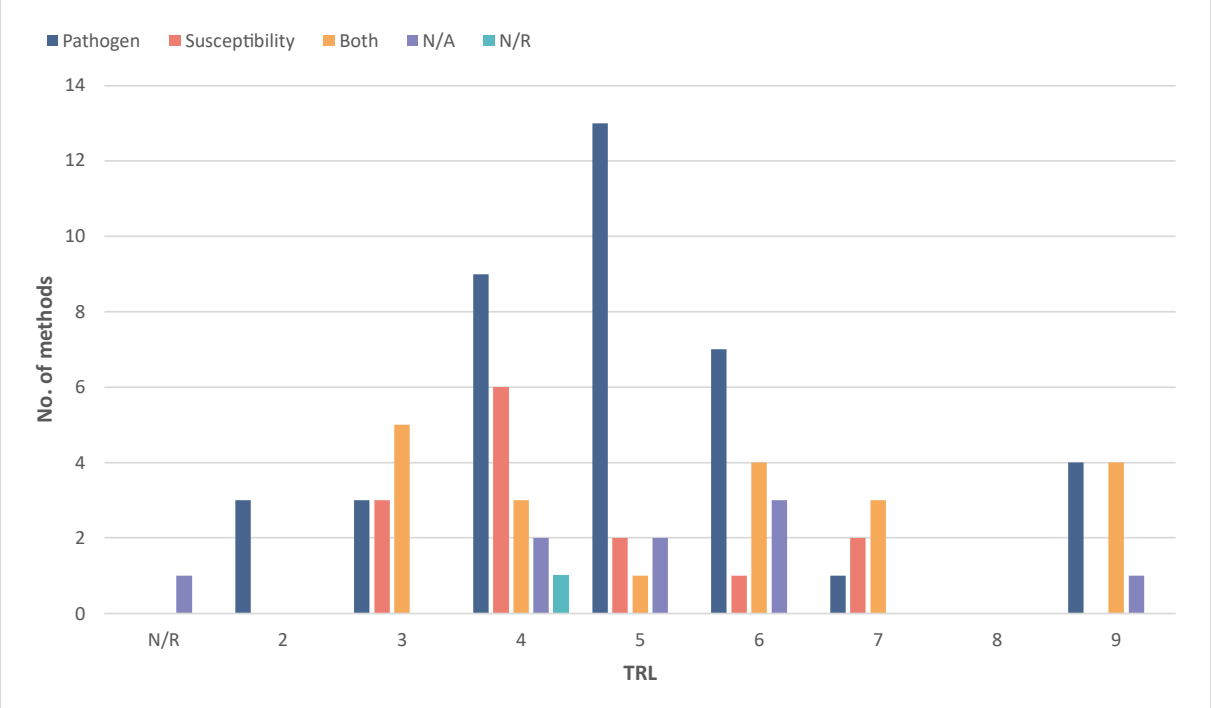
Nine methods were identified as being TRL 9. Of these, four were able to identify pathogens and four identified both pathogens and susceptibility, while one was categorised as N/A. Six methods were identified as being TRL 7, with two of these able to identify susceptibility (mPCR + P-AST and Urinary infection decision support tool), one able to identify pathogens (Rapid phenotypic UTI AST), and three able to identify both pathogens and susceptibility (iPRISM,

Metagenomics nanopore sequencing and Targeted next-generation sequencing (tNGS) urine panel).

Fifteen methods were identified at TRL 6. Of these, seven were able to identify pathogens, one susceptibility, and four both pathogens and susceptibility, while three were categorised as N/A. Twenty-one methods were mapped to TRL 4, with nine of these being able to identify pathogens, six able to identify susceptibility, three able to identify both pathogens and susceptibility, and two categorised as N/A.

Eleven methods were mapped as being TRL 3. Of these, three were able to identify pathogens, three susceptibility, and five both pathogens and susceptibility. Three methods were identified as being TRL 2, with all three able to identify pathogens (Electrochemiluminescence biosensor (ECL signal measured of the MPI-E electrochemiluminescence analyser), Hyperspectral imagining and random forest (HSI-RF) and MSP-based biosensor) and one method was N/R for TRL and categorised as N/A (MALDI-TOF with sonicated urine samples).

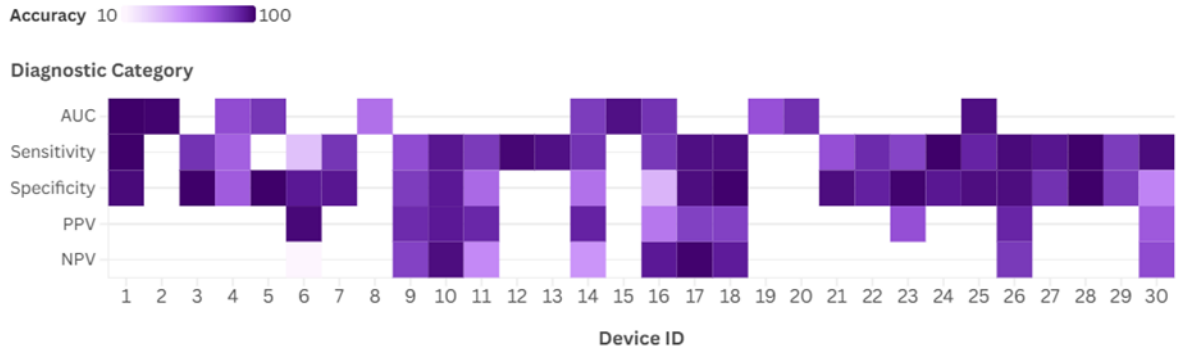
Figure 7. Technology Readiness Levels of included methods distributed by ability to detect pathogens or AMR susceptibility



Diagnostic accuracy

Diagnostic accuracy data, covering sensitivity, specificity, area under the curve (AUC), positive predictive value (PPV), and negative predictive value (NPV), were available for 69 records reporting on technologies (technologies and methods) with TRL >3. Two separate heatmaps were generated to illustrate performance: one for distant-horizon technologies (TRL 4–7; n=30) and another for imminent-horizon technologies (TRL 8–9; n=32) (Figure 8 and Figure 9, respectively). In the few cases where multiple records reported diagnostic accuracy for the same technology (n=3), averages were calculated. Similar approaches were applied where diagnostic data were reported for a single device across different populations or clinical targets.

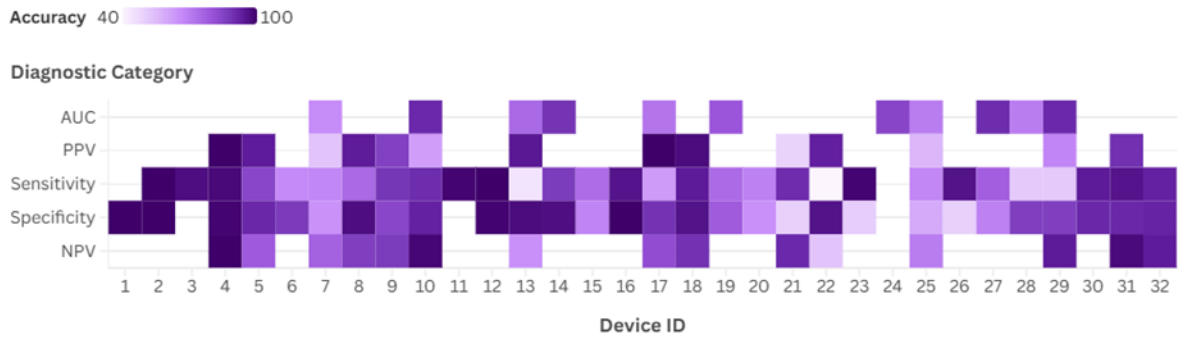
Figure 8. Technologies (products and methods) at TRL 4-7 with available diagnostic data. Accompanying figure legend in the table below.



Number	Technology (products and methods) Name
1	Cation dye-triggered electrokinetic AuNP agglutination (CD-TEAA)
2	Dual fluorescence turn-on sensor array
3	LVSi-RD (Large Volume Solution Scattering Imaging - Rapid Detection)
4	Machine-learning Decision Support - Oxford, UK
5	Machine learning AMR prediction model - Cambridge, USA
6	Negative urinalysis
7	ANTIBIOLOG
8	AMR prediction model - GASLINI, Italy
9	Rapid immunochromatographic test
10	SERS-active gold-coated PVDF membrane filter + Raman spectrometer
11	16S ribosomal RNA gene sequencing
12	IoT-Enhanced Machine Learning System - Galgotias, India
13	Raman spectroscopy
14	Nicolet-i10 Fourier transform infrared spectroscopy + Random Forest

15	Optical - KNeighborsClassifier algorithm
16	CRP and Systemic immune-inflammation index (SII)
17	Custom LAMP panel - DZIF, Germany
18	LCD platform - LAMP + centrifugal disk system (LCD)
19	Machine learning prediction model - Ajou, South Korea
20	Machine learning-based diagnostic framework - UoT Sydney, Australia
21	Reporter phage-based bioluminescence assay
22	Dynamic Surface-Enhanced Raman Spectroscopy
23	Engineered reporter phages
24	Fluorescent distance-based paper device (qLAMP)
25	DETECT (dual-enzyme trigger-enabled cascade technology)
26	iPRISM
27	Metagenomics nanopore sequencing
28	Multiplex High Resolution Melting Assay (MHRM)
29	Rapid phenotypic UTI AST
30	Targeted next-generation sequencing (tNGS) urine panel - Guangzhou, China

Figure 9. Technologies (products and methods) TRL 8-9 with available diagnostic data. Accompanying figure legend in the table below.



Number	Technology (products and methods) Name
1	Applied Biosystems™ OpenArray™ platform
2	CHROMagar Orientation Medium
3	D3 ArrayTM-UTI
4	Direct-to-PCR (D2P) extraction-free nucleic acid processing technology
5	Human Lipocalin-2/NGAL, human IL-8/CXCL8, human IL-1β/IL-1F2 - Quantikine ELISA kits
6	Human Lipocalin-2/NGAL ELISA Kit - Quantikine
7	Human sTLR4, sTLR5, IL-8 Platinum ELISA Kit
8	E-Test
9	Lodestar DX

10	Urine dipstick
11	Urine culture
12	MALDI-TOF MS + lateral flow immunochromatography
13	MBT STAR-Cepha kit
14	MinION R9.4.1 flow cells
15	Amazon Human IL-6 and IL-8 ELISA Kit
16	MultiPath analyzer
17	MUS-3600 full-automatic urine analyser
18	NANOPLEX
19	sTREM-1 assay- ELISA
20	Oxford Nanopore MK1c with Resistance-Associated Sequence Elements (RASE) pipeline
21	UriSed 3 Pro urine microscopic analyzer
22	PATHFAST Immunoanalyser Presepsin Kit
23	PCR (QuantStudio 7 or 12 or KingFisher)
24	PGE2 ELISA
25	PhiCal® Calprotectin
26	Piezoelectric electronic noses (e-noses)
27	Quantum Blue sCal quantitative lateral flow assay
28	Siemens-Dimention + Sysmex XN-1000
29	Sysmex UF-5000
30	UTI biomarker panel-ELISA
31	U-treat
32	Vivalytic One Analyser

Turnaround times

Long turnaround times for technologies used in UTI diagnosis can lead to incorrect antibiotic prescribing, ultimately contributing to AMR. Adopting technologies with shorter turnaround times can empower healthcare providers to make better prescribing decisions and improve antimicrobial stewardship.[15] Turnaround times for UTI diagnosis and AMR testing among technologies identified in this horizon scan ranged from 30 seconds to over 48 hours. The dual fluorescence turn-on sensor array (TRL 4) reported the shortest turnaround time at 30 seconds. Technologies including aluminium foil integrated with pegylated gold nanoparticles with surface-enhanced Raman scattering (TRL 3), an electro fluidic capacitor-based biosensor for prostaglandin E2 detection (TRL 4), holographic lens-free imaging (TRL 6), the USENSE platform (TRL 6), and piezoelectric electronic noses (TRL 9) reported turnaround times of a few

minutes. Technologies reporting turnaround times of one hour or less for UTI diagnosis or AMR susceptibility testing are presented in Table 4.

Table 4. Turnaround time of identified technologies by TRL and pathogen or susceptibility detection capability

Technology name	Developer	Turnaround time	Pathogen, AMR susceptibility detection, or biomarker detection
Technology Readiness Level 9			
Direct-to-PCR (D2P)	Scienetix (USA)	45 minutes	Both
Lodestar DX	Llusern Scientific Limited (UK)	35 minutes	Pathogen
MBT STAR-Cepha kit	Bruker Daltonics (Germany)	<30 minutes	Susceptibility
NANOPLEX	FluoretiQ (UK)	15 minutes	Pathogen
PA-100 AST System	Sysmex (UK)	30-45 minutes	Both
PATHFAST Immunoanalyzer Presepsin Kit	PATHFAST (Japan)	< 17 minutes	N/A (biomarker detection)
Piezoelectric electronic noses (e-noses)	LLC "Sensorika–Novye Technologii" (Russia)	3 minutes	N/A (biomarker detection)
Quantum Blue sCal, Quantum Blue reader	BÜHLMANN Laboratories AG (Switzerland)	20 minutes	N/A (biomarker detection)
U-treat	Test and Treat (UK)	< 1 hour	Both
VITEK 2	N/R	<1 h	Both
Technology Readiness Level 7			
DETECT (dual-enzyme trigger-enabled cascade technology)	Division of Infectious Diseases and Vaccinology, School of Public Health, University of California, Berkeley (USA)	30 minutes	Both
Technology Readiness Level 6			
Customised LAMP panel	N/R	30 minutes	Both
Holographic lens free imaging (LFI)	Department of Biomedical Engineering, Johns Hopkins University(USA)	2 minutes	Pathogen
PANTOMIM (Plasmonic Array Nanohole Technology on Metal-Insulator-Metal)	Imperial College London (UK)	Within 15 minutes	Pathogen
USENSE platform	University of Texas (USA)	< 5 minutes	N/A (biomarker detection)
Technology Readiness Level 5			

Fluorescently labelled enterocin K1 flow cytometry assay	Norwegian University of Life Sciences (Norway)	<40 minutes	Pathogen
MALDI-TOF MS-based algorithm profiling coupled with Fc-MBL@Fe_3O_4 magnetic enrichment	Ningbo University (China)	30 minutes	Pathogen
Nicolet-iN10 Infrared Microscope	Thermo Fisher Scientific; in-house algorithm development by Ben-Gurion University of the Negev, Afeka Tel-Aviv Academic College of Engineering, Shamoon College of Engineering (Israel)	40 minutes	Both
Pseudomonas aeruginosa-specific capture assay	N/R	~1 h	Pathogen
Technology Readiness Level 4			
Cation Dye-Triggered Gold Nanoparticle Electrokinetic Agglutination Analysis (CD-TEAA)	NMPA Key Laboratory for Research and Evaluation of Drug Metabolism, Guangdong Provincial Key Laboratory of New Drug Screening, School of Pharmaceutical Sciences, Southern Medical University, Guangzhou (China)	30 mins for pathogen identification, 2.5 hours for AST	Both
Disposable fiber-optic plasmonic sensor	N/R	20 minutes	Pathogen
Dual fluorescence turn-on sensor array	State Key Laboratory of Natural Medicines, National R&D Center for Chinese Herbal Medicine Processing Department of Food Quality and Safety, College of Engineering (China)	30 seconds	Pathogen
Electro fluidic capacitor-based biosensor for prostaglandin E2 detection	University of Texas (USA)	< 5 minutes	N/A

LVSi-RD (Large Volume Solution Scattering Imaging - Rapid Detection)	Biodesign Center for Bioelectronics and Biosensors, Arizona State University (USA)	10 minutes	Pathogen
Nano electrokinetic paper-based analytic device (NEK-PAD) as a sample module of a Rapid and Accurate Nano electrokinetic Diagnostic System (RANDx)	Seoul National University (South Korea)	7 minutes	Both
Rapid immunochromatographic test for Escherichia coli detection	Universidad de la República (Uruguay)	25 minutes	Pathogen
SERS-active gold-coated PVDF membrane filter with handheld Raman spectrometer	Imperial College London (UK)	15 minutes	Pathogen
Technology Readiness Level 3			
Aluminium foil integrated with pegylated AuNP SERS	Department of Chemistry, Chaudhary Charan Singh University (India)	A few minutes	Pathogen
SERS nanowire chip + machine learning classification platform	Indian Institute of Technology Delhi & UiT. The Arctic University of Norway (Norway)	20 minutes	Both
Technology Readiness Level 2			
Magnetostrictive particles (MSP) based biosensor	Materials Research and Education Center, Auburn University (USA)	20 minutes	Pathogen
Technologies were included in the 'not applicable' (N/A) category if they did not directly detect pathogens, susceptibility or both (for example those that detect specific biomarkers).			

Analysis of biomarkers

A total of 12 products and five methods used biomarker based methods. Seventeen unique biomarkers were identified within the products. The biomarkers with the highest frequency were interleukin-8 (IL-8) (n=3), neutrophil gelatinase-associated lipocalin (NGAL) (n=2), IL-1β (n=2) and calprotectin (n=2) (Figure 10). Seven unique biomarkers were identified within the methods. Each biomarker present in the methods occurred only one time, these were C-reactive protein (CRP), systemic immune-inflammation index (SII), PCT, outer membrane

protein A (OmpA), RNA polymerase-binding transcription factor DksA, prostaglandin E2 (PGE2) and indole (Figure 11).

Figure 10. Range of biomarkers used by included products

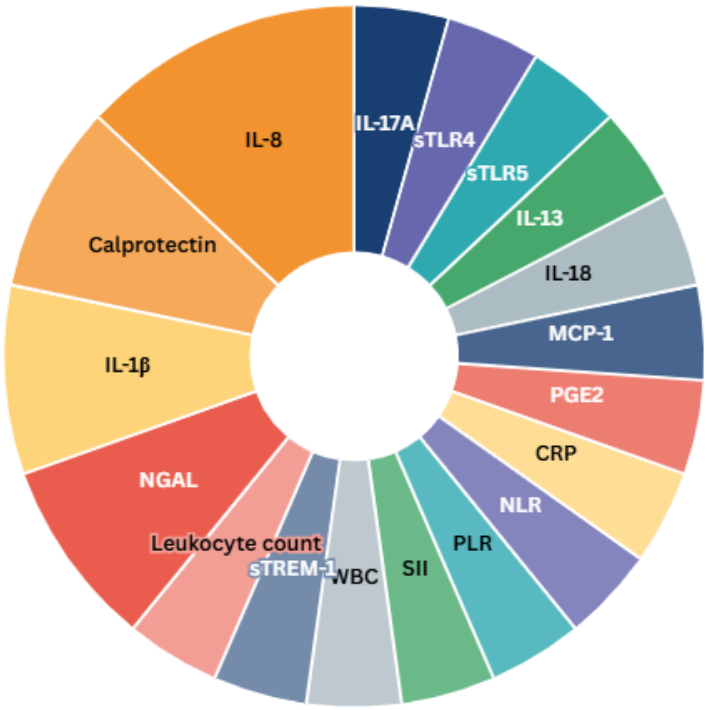
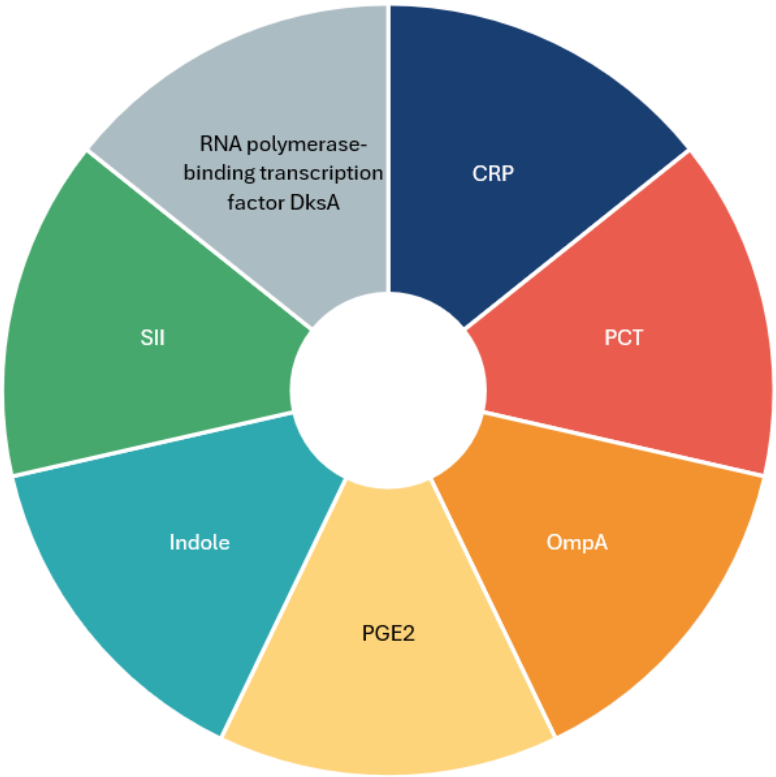


Figure 11. Range of biomarkers used by included methods



There were six products which detected a single biomarker. The other six products were able to detect more than one biomarker a time, ranging from three to five biomarkers (Table 5). Three methods were identified which detected a single biomarker. The other two methods were able to detect two biomarkers at a time (Table 6).

Table 5. Biomarkers identified by product

Technology name (Developer)	Biomarkers
Human IL 17 ELISA Kit (Sigma Aldrich)	IL-17A
Human Lipocalin-2 / NGAL Quantikine ELISA Kit, human IL-8 / CXCL8 Quantikine ELISA Kit, human IL-1β / IL-1F2 Quantikine ELISA kit; (Pathnostics)	NGAL, IL-8, IL-1β
Human Lipocalin-2/NGAL ELISA Kit (R&D Systems)	NGAL
Human sTLR4 ELISA Kit, Human sTLR5 ELISA Kit (BT Lab Biotech Co), Human IL-8 Platinum ELISA Kit (Bender MedSystems GmbH Campus)	sTLR4, sTLR5, IL-8
LEGENDplex Human Inflammation Panel 1, BioLegend-HU Th Cytokine Panels (BioLegend)	IL-1β, IL-8, IL-13, IL-18, MCP-1
PGE2 ELISA (Enzo Life Sciences)	PGE2
PhiCal® Calprotectin (Immundiagnostik AG)	Calprotectin
Quantum Blue sCal, Quantum Blue reader (BÜHLMANN Laboratories AG)	Calprotectin
Siemens Dimention (Siemens Healthineers AG.), Sysmex XN-1000 (Sysmex Corporation)	CRP, NLR, PLR, SII, WBC
sTREM-1 assay- ELISA (SunRed Biotechnology Co., Ltd)	sTREM-1
UriSed 3 Pro (77 Elektronika Kft)	Leukocyte count
USENSE platform (Developer N/R)	PGE2

Table 6. Biomarkers identified by method

Technology name (Developer)	Biomarkers
CRP and Systemic immune-inflammation index (SII) (Dr. Sami Ulus Training and Research Hospital)	CRP, SII
Serum procalcitonin (PCT) assay (Developer N/R)	PCT
2D-gel electrophoresis combined with LC-MS/MS (King Abdulaziz University)	OmpA, RNA polymerase-binding transcription factor DksA
Electro fluidic capacitor-based biosensor for prostaglandin E2 detection (University of Texas)	PGE2
S-nitroso-N-acetyl penicillamine (SNAP)-impregnated silicone urinary catheter for colorimetric indole/E. coli detection (Virginia Commonwealth University)	Indole

Analysis of technologies (products and methods) that use Artificial Intelligence (AI) or Machine Learning (ML)

Our scan contains 18 records describing technologies (products and methods) that apply AI and/or ML to the diagnosis or management of UTI and bacteriuria. Each entry corresponds to either a methodological approach (algorithmic workflow or predictive model) or a developed diagnostic product. Two products and 16 methods describing algorithms and analytical pipelines integrated with microbiological, genomic, or proteomic diagnostic approaches were included.

The dataset shows a dominance of classical supervised ML methods, particularly Random Forest (4 occurrences), logistic regression variants (6 occurrences combined), and gradient boosting models (2 occurrences). These algorithms are often combined with feature engineering techniques (e.g., Principal Component Analysis, PCA) and data-specific preprocessing pipelines, including image processing and hyperspectral analysis, indicating that AI is primarily applied as a classification or prediction layer on top of microbiological, genomic, imaging, or clinical datasets rather than as deep learning architectures (Table 7).

Table 7. AI/ML methods used in UTI

Category	AI / ML Method	Occurrence
Supervised machine learning algorithms	Random Forest (RF)	**4**
	Logistic Regression (LR)	**3**
	Multinomial Logistic Regression	**2**
	Lasso Logistic Regression (LLR)	**1**
	Extreme Gradient Boosting (XGBoost / XGB)	**2**
	Ensemble Bagging Decision Tree	**1**
	TabNet	**1**
Feature engineering / dimensionality reduction	Principal Component Analysis (PCA)	**2**
Machine learning frameworks	Interpretable Machine Learning (Biotia-DX)	**1**

Computer vision / image processing methods	Laplacian of Gaussian filter	**1**
	Kalman Filter	**1**
	Temporal local minimal subtraction	**1**
Data preprocessing / augmentation	Image augmentation (rotation, shear, zoom, flip)	**1**

Additional entries refer generically to ML frameworks or pipelines, but do not specify the algorithm. Overall, from the included records we infer that traditional supervised ML algorithms dominate the field, with limited evidence of deep learning or neural network applications.

Most technologies were at TRL 4–6, representing laboratory-validated prototypes or proof-of-concept systems. Only two technologies have reached TRL 9, indicating fully operational diagnostic products. Overall, this distribution suggests that the field remains in a translational development phase, with limited technologies currently implemented in routine clinical practice.

Our results covered three main diagnostic strategies: pathogen identification, where AI is applied to sequencing, proteomic, or microbiome data to detect infectious organisms; antimicrobial susceptibility prediction, where ML models estimate antibiotic resistance patterns using genomic or phenotypic datasets; and integrated diagnostics, which simultaneously predict pathogen identity and antimicrobial susceptibility, representing the most clinically valuable but still emerging approach.

Overview of pathogens detected by the included technologies in line with the UK Health Security Agency (UKHSA) priority list

The UK Health Security Agency (UKHSA) has released the Priority Pathogen Families Research and Development (R&D) Tool[3] to highlight pathogen families where AMR poses particular concern and to emphasise the ongoing need for rapid, accurate diagnostic technologies to support clinical decision-making.

Among the priority bacteria identified as research targets for urinary tract infections (UTIs), including cystitis and pyelonephritis, are uropathogenic *Escherichia coli* (UPEC) and

Acinetobacter baumannii (*A. baumannii*). The following sections presents the technologies identified for these two priority pathogens on the UKHSA list.

Acinetobacter baumannii

Acinetobacter baumannii is a gram-negative bacterium classified by UKHSA as a critical AMR priority in UTIs, largely due to its resistance to carbapenems and third-generation cephalosporins—antibiotics often reserved as last-line treatments.[16] Its capacity for multidrug resistance, combined with robust biofilm formation, presents substantial therapeutic challenges highlighting the need for rapid diagnostic tests capable of reliably detecting this pathogen.

Our horizon scan identified 14 technologies (products and methods) with the ability to detect *A. baumannii*. Of these, 5 products (36%) are TRL 9. Two are designated as RUO (Illumina NextSeq550, Illumina, USA; Vivalytic System (UTI cartridge), Bosch Healthcare Solutions GmbH, Germany), one CE-marked (Guidance UTI, Pathnostics, USA), one FDA cleared (MultiPath analyzer, First Light Diagnostics), and one (DOCLAB 2.0 UTM PCR Panel, Doc Lab Inc., USA) with no reported regulatory status but currently undergoing clinical validation and utility assessment (clinical trial ID NCT06996301). The remaining nine technologies corresponded to methods and span TRLs 3–9 (see Table 85), indicating active development across multiple stages of maturity.

Table 8. Methods capable of identifying A. baumannii at TRL 3-9.

Technology	Developer	Country
Technology Readiness Level 9		
PCR	Dicentra	Canada
Technology Readiness Level 7		
Targeted next-generation sequencing (tNGS) urine panel	Guangzhou DaAn Clinical Laboratory Center Co. Ltd	China
Technology Readiness Level 6		
LCD platform- "Loop-mediated isothermal amplification (LAMP) and a centrifugal disk system (LCD)"	Fosun Diagnostics Co., Ltd.	China
	N/R	N/R

Dynamic Surface-Enhanced Raman Spectroscopy		
UTI high-throughput multiplex genetic detection system (UTI-HMGS)	N/R	China
Technology Readiness Level 5		
Universal Microbial Internal Transcribed Spacer (ITS) Identification System	University of Michigan	USA
Technology Readiness Level 4		
Dual fluorescence turn-on sensor array	National R&D Center for Chinese Herbal Medicine Processing Department of Food Quality and Safety	China
Technology Readiness Level 3		
"Turnon" terbium (Tb3+) photoluminescence assay supported on a paper-based platform	Indian Institute of Science	India
Compound Raman microscopy	Beijing Advanced Innovation Center for Biomedical Engineering, Beihang University	China

Escherichia coli

Uropathogenic *Escherichia coli* (UPEC), a gram-negative bacterium commonly found in the lower intestine, is the leading causative agent of UTIs, accounting for approximately 75% of uncomplicated cases. In this horizon scan, we identified 86 technologies capable of detecting *E. coli* as a pathogenic target. Although these were not always reported specifically as UPEC, the UTI-focused context of the studies suggests that most results are UPEC-centric, even if detection could extend to other E. coli subgroups (e.g., enterotoxigenic E. coli).

Diagnostic development for *E. coli* UTIs is active across all stages of maturity. We identified 28 technologies (both products and methods) in early development (TRL 2–4), 26 in mid-stage development (TRL 5–7), and 32 in late-stage development (TRL 8–9). Technologies at the later stages are presented in the table below.

Table 9. All unique technologies at a TRL ≥ 8 capable of identifying E. coli UTI infections

Technology Name	Developer	Country of Development
Technology Readiness Level 9		
Acuitas AMR gene panel	OpGen	USA
Biotia Urine Assay. (BIOTIA-DX)	Biotia Inc.	USA
CHROMagar	Becton Dickinson	USA
Direct-to-PCR (D2P)	Scienetix	USA
DocLab UTM 2.0	Doc Lab Inc	N/R
E-test strips	BioMerieux	N/R
Expanded Quantitative Urine Culture (EQUC)	Loyola University	USA
Guidance UTI	Pathnostics	USA
iFAST (impedance-based fast antimicrobial susceptibility test)	iFast Diagnostics	United Kingdom
Illumina NextSeq 550	Illumina	USA
Lodestar DX	Llusern Scientific Limited	United Kingdom
MALDI Biotyper	Bruker Daltonics	Egypt
Illumina MiSeq 16S rRNA sequencing + MinION	Illumina; Oxford Nanopore Technologies	United Kingdom
MALDI-TOF MS rapid AST	Bruker Daltonics	Germany
MBT STAR-Cepha kit	Bruker Daltonics	Germany
Metagenomic next-generation sequencing (mNGS)	Henan Province People's Hospital	China
MInION (MinION sequencing system with Flongle flowcell)	Oxford Nanopore Technologies	Norway
MultiPath analyzer	First Light Diagnostics	USA
MUS-3600 full-automatic urine analyser	Dirui Industrial Co., Ltd.	China
NANOPLEX	FluoretiQ	N/R
Oxford Nanopore MK1c with Resistance-Associated Sequence Elements (RASE) pipeline	Oxford Nanopore Technologies; The Ottawa Hospital Research Institute et al.	Canada
PA-100 AST System	Sysmex	United Kingdom
PCR	Dicentra	Canada
Quantum Blue sCal, Quantum Blue reader	BÜHLMANN Laboratories AG	Switzerland; Croatia
Sysmex automated urine analyzer (undetermined model)	Sysmex	N/R
U-AST kit	CSIR-Central Salt & Marine Chemicals Research Institute	India
Urine culture	N/R	Switzerland
Uro-Quick system, Vitek-MS system	Alifax, bioMerieux	N/R
VITEK 2	BioMerieux	N/R
Vivalytic system	Bosch Healthcare Solutions GmbH	Germany

MALDI; 16S rRNA sequencing; WGS; UTI chromogenic agar; API 20E	BioMerieux; Illumina; Oxford Nanopore Technologies	N/R
Technology Readiness Level 8		
RapidPlate	MicroplateDX	Scotland

Note: Illumina MiSeq 16S rRNA sequencing + MinION (Illumina; Oxford Nanopore Technologies) is two technologies that were used in a hybrid sequencing approach

Staphylococcus aureus

While *E. coli* is the predominant Gram-negative bacterium responsible for UTIs, the leading Gram-positive pathogens are Staphylococcus species, particularly *S. aureus* and coagulase-negative staphylococci such as *S. saprophyticus*. *S. saprophyticus* is the second most common cause of UTIs in sexually active women aged 15–30 years, whereas *S. aureus* accounts for approximately 1–3% of cases—a sharp contrast to the ~75% attributable to UPEC. *S. aureus* is included on the UKHSA bacterial priority list due to its significant AMR threat across multiple diseases, including cellulitis, endocarditis, and pneumonia.[3] Importantly, untreated *S. aureus* UTIs can progress to severe or even fatal outcomes, underscoring the need for rapid and accurate diagnostics.

In this horizon scan, we identified 24 technologies capable of detecting *S. aureus*. Of these, 38% (n=9) were TRL 9, 33% (n=8) were TRLs 5–7, 25% (n=6) were TRLs 2–4, and one N/A. Notably, 67% (n=6) of the TRL 9 technologies were also able to detect coagulase-negative staphylococci. Among the TRL 9 technologies, one (Guidance UTI, Pathnostics, USA) is CE-marked, one (MultiPath Analyzer, First Light Diagnostics, USA) has FDA clearance, one (MALDI Biotyper, Bruker Daltonics, USA) is CE-marked and FDA cleared, and three are RUO (Illumina NextSeq 550, Illumina; MinION sequencing system with Flongle flowcell, Oxford Nanopore Technologies; Vivalytic system, Bosch Healthcare Solutions GmbH).

Antibiotic Resistance detection

Ninety-six (~70%) technologies identified in this scan either did not specify the antibiotics tested, or tested other parameters apart from antibiotics, e.g. biomarkers. Among those that did, 32 (23%) tested individual antibiotics, 10 (6%) were reported to test both individual antibiotics and antibiotic classes, while 2 (1%) technologies reported only the antibiotic class tested. Table 9 below summarises the antibiotics or antibiotic classes assessed by each unique technology. Where a technology was reported in multiple records, the version testing the greatest number of antibiotics was included.

Table 10. Antibiotic numbers and classes detected for resistance by technologies

Reference	Technology name	Developer	Number of specific antibiotics	Number of classes of antibiotics	Names of antibiotics reported	Classes of antibiotics reported
Technology Readiness Level 9						
Varney, 2024	MALDI; 16S rRNA sequencing; WGS; UTI chromogenic agar; API 20E	BioMerieux; Illumina; Oxford Nanopore Technologies; N/R	20	N/R	Ampicillin, piperacillin, amoxicillin, cefoxitin, cefixime, ceftriaxone, cefotaxime, ceftazidime, meropenem, doripenem, aztreonam, ciprofloxacin, norfloxacin, amikacin, gentamicin, tobramycin, tigecycline, trimethoprim chloramphenicol, nitrofurantoin	N/R
Korman, 2023	Guidance UTI	Pathnostics	19	3	Ampicillin, methicillin, vancomycin	Quinolones, fluoroquinolones, carbapenems
Mohajeri, 2024	VITEK 2 system	bioMérieux	17	N/R	Penicillin, ampicillin, clindamycin, erythromycin, tetracycline, , ampicillin, benzylpenicillin, tigecycline, vancomycin, cefixime, ceftriaxone, sulfamethoxazole/trimethoprim, moxifloxacin, levofloxacin, linezolid, chloramphenicol	N/R

					col, teicoplanin	
Behcet, 2021	VITEK 2. (BD Phoenix, BACTEC,VITEK®2 Compact)	bioMérieux / Becton Dickinson	12	N/R	Trimethoprim/sulfamethoxazole, ciprofloxacin, ceftazidime, ceftriaxone, cefixime, cefuroxime, ampicillin, gentamicin, piperacillin/tazobactam, nitrofurantoin, fosfomycin, amikacin	N/R
Carroll, 2025	Oxford Nanopore MK1c with Resistance-Associated Sequence Elements (RASE) pipeline	Oxford Nanopore Technologies; The Ottawa Hospital Research Institute et al, Canada	9	N/R	Amoxicillin-clavulanic acid, cefazolin, ceftriaxone, ciprofloxacin, gentamicin, meropenem, nitrofurantoin, piperacillin-tazobactam, trimethoprim - sulfamethoxazole	N/R
Bock, 2023	iFAST (impedance-based fast antimicrobial susceptibility test)	iFast Diagnostics	8	N/R	Co-amoxiclav, amoxicillin, ceftazidime, cefalexin, ciprofloxacin, gentamicin, nitrofurantoin, trimethoprim	N/R
Riedel, 2021	Acuitas AMR gene panel	OpGen	5	N/R	Ampicillin, ciprofloxacin, ceftriaxone, gentamicin, nitrofurantoin	N/R
Burg, 2022	MultiPath analyzer	First Light Diagnostics	5	N/R	Ciprofloxacin,	N/R

					cefpodoxime, nitrofurantoin, trimethoprim-sulfamethoxazole, linezolid	
NCT06625268, 2024	PA-100 AST System	Sysmex	5	N/R	Amoxicillin/clavulanic acid, ciprofloxacin, fosfomycin, nitrofurantoin, and trimethoprim	N/R
Behere, 2024	U-AST kit	CSIR-Central Salt & Marine Chemicals Research Institute; Academy of Scientific and Innovative Research, India	5	N/R	Ampicillin, amoxicillin, amikacin, ciprofloxacin, co-trimoxazole	N/R
Ota, 2023	MBT STAR-Cepha kit	Bruker Daltonics	4	N/R	Cefotaxime, ceftazidime, imipenem, meropenem	N/R
John, 2022	Urine culture	N/R	4	N/R	Ceftriaxone, ciprofloxacin, co-trimoxazole, co-amoxicillin	N/R
Spangler, 2024	DocLab UTM 2.0	Doc Lab Inc	3	2	Sulfamethoxazole, trimethoprim, vancomycin	Carbapenem, beta lactams
Barnes, 2021	Expanded Quantitative Urine Culture (EQUC)	Loyola University, USA	3	2	Nitrofurantoin, trimethoprim/sulfamethoxazole, fosfomycin	Cephalosporins, fluoroquinolones
Zhang L, 2022	MinION (MinION Mk1C in R9.4.1 flow cells)	Oxford Nanopore Technologies	3	3	Nitrofurantoin, cotrimoxazole, vancomycin	Fluoroquinolone, β-lactam, cephalosporins,

Kardjadj, 2025	PCR	Thermo Fisher	3	2	Vancomycin, sulfamethoxazole, trimethoprim	Beta lactams, carbapenems,
Hartmann, 2024	Vivalytic system	Bosch Healthcare Solutions GmbH	3	N/R	Trimethoprim, methicillin, vancomycin	N/R
Almas, 2025	Direct-to-PCR (D2P)	Scienetix	1	1	cefotaxime	Beta lactams
Somorin, 2022	Etest strips	BioMerieux	1	N/R	Trimethoprim	N/R
Technology Readiness Level 8						
Domingo-Roca, 2023	RapidPlate	Microplate DX	5	N/R	Streptomycin, trimethoprim, amoxicillin, fosfomycin, gentamicin	N/R
Dedhia, 2023	QuantStudio 12K Flex	Thermo Fisher Scientific	1	12	Methicillin	Aminoglycosides, tetracyclines, sulphonamides, macrolides, lincosamides, streptogramins, ketolides, oxazolidinones, quinolones, fluoroquinolones, glycopeptides, beta-lactams (classes A–D)
Technology Readiness Level 7						
Vollstedt, 2021	P-AST (Multiplex polymerase chain reaction (mPCR) + pooled antibiotic sensitivity testing)	N/R	14	N/R	N/R	N/R
Jackson, 2021	DETECT (Dual-enzyme trigger-	BioAmp Diagnostics Inc	3	N/R	Ciprofloxacin, nitrofurantoin,	N/R

	enabled cascade technology)				trimethoprim /sulfamethoxazole	
Chang, 2025	Targeted next-generation sequencing (tNGS) urine panel	Guangzhou DaAn Clinical Laboratory Center Co. Ltd, China. and other collaborators	3	2	Vancomycin, methicillin, penicillin	Cephalosporins, carbapenems
Halachmi, 2024	iPRISM (Intensity-based phase-Shift reflectometric interference measurements)	Technion Israeli Institute of Technology, Israel	2	N/R	Ciprofloxacin, gentamicin	N/R
Technology Readiness Level 6						
Kim, 2021	Machine learning prediction model	Ajou University, Korea	8	N/R	Ampicillin ceftriaxone ciprofloxacin gentamicin levofloxacinnitrofurantoin tetracyclinetrimethoprim/sulfamethoxazole	N/R
Chen, 2023	LCD platform-"Loop-mediated isothermal amplification (LAMP) and a centrifugal disk system (LCD)"	Fosun Diagnostics Co., Ltd.	6	N/R	Imipenem meropenem ceftazidime cefotaxime cefoxitin vancomycin	N/R
Shumeiko, 2021	BactoSpin	BactoSpin Ltd.	3	N/R	Ampicillin, gentamicin, amikacin	N/R
Sharaha, 2022	Fourier-transform infrared (FTIR)	N/R	2	N/R	Cefotaxime, ceftazidime	N/R

	spectroscopy					
Sun, 2021	UTI high-throughput multiplex genetic detection system (UTI-HMGS)	N/R	2	N/R	Methicillin vancomycin	N/R
Technology Readiness Level 5						
Abu-Aqil, 2023	Nicolet-iN10 Infrared Microscope	Thermo Fisher Scientific; in-house algorithm development by Ben-Gurion University of the Negev, Afeka Tel-Aviv, Israel	3	N/R	Ceftazidime ciprofloxacin gentamicin	N/R
Choi, 2022	16S ribosomal RNA gene sequencing	Jeju National University, South Korea	N/R	1	N/R	Extended spectrum beta-lactams
Technology Readiness Level 4						
Bagnasco, 2022	Prediction model for early detection of drug-specific resistance	IRCCS Istituto Giannina Gaslini, Italy	17	N/R	Amikacin, amoxicillin-clavulanate ampicillin cefixime cefuroxime cefotaxime ceftazidime ciprofloxacin fosfomycin tromethamine gentamicin meropenem nitrofurantoin cotrimoxazole piperacillin-tazobactam teicoplanin vancomycin	N/R

Crane, 2024	Electrochemical Lab-on-a-Chip (LOC) with resazurin bulk-modified screen-printed electrodes and antibiotic-loaded hydrogels	Manchester Metropolitan University, UK	7	N/R	Cephalexin ceftriaxone colistin gentamicin piperacillin trimethoprim vancomycin	N/R
Yang, 2023	Machine-learning Decision Support	University of Oxford, UK	4	4	Nitrofurantoin co-trimoxazole ciprofloxacin levofloxacin	4
Wei, 2024	(CD-TEAA) Cation Dye-Triggered Gold Nanoparticle Electrokinetic Agglutination Analysis	NMPA Key Laboratory for Research and Evaluation of Drug Metabolism, Hong Kong	3	N/R	Ampicillin ceftriaxone ofloxacin	N/R
Harris, 2023	Multiplex real-time fluorescence PCR	Clemson University, USA	2	5	Methicillin vancomycin	Fluroquinolones, macrolides, beta-lactams, cephalosporin, cephamycin
Alsubhi, 2021	2D-gel electrophoresis combined with LC-MS/MS	King Abdulaziz University, Saudi Arabia	1	N/R	Tetracycline	N/R
Crane, 2021	Resazurin bulk modified screen-printed macroelectrodes (R-SPEs)	Manchester Metropolitan University, UK	1	N/R	Gentamicin sulphate	N/R

Technology Readiness Level 3						
Walls, 2021	A 3D-printed multichannel disposable cassette on a resonator	Microbial Pulse Diagnostics	6	N/R	Nitrofurantoin trimethoprim amoxicillin levofloxacin cefoxitin ampicillin	N/R
Drabinska, 2022	GC-MS/MOS system (solid-phase microextraction-gas chromatography-mass spectrometry/metal oxide sensor system)	University of the West of England, UK	2	N/R	Cefotaxime cefepime	N/R
Werneburg, 2024	Machine learning algorithm	Department of Urology, Glickman Urological and Kidney Institute, USA	2	N/R	Trimethoprim-sulfamethoxazole Nitrofurantoin	N/R
Zhang W, Zhang J, 2022	AI-stimulated Raman scattering metabolic imaging system	Institute of Medical Photonics, Beijing, China	1	N/R	Gentamicin	N/R
Zhang W, Sun H, 2022	Compound Raman microscopy	Institute of Medical Photonics, Beijing, China	1	N/R	Gentamicin	N/R

N/R – Not reported in original source of information

Overall, the identified technologies were able to test the sensitivity for 50 different antibiotics (Table 11).

Table 11. Unique antibiotics tested by the included technologies

Antibiotic	Number of Technologies
Gentamicin	21
Ciprofloxacin	19
Nitrofurantoin	18
Ampicillin	15
Cotrimoxazole (trimethoprim/sulfamethoxazole)	15
Ceftazidime	12
Ceftriaxone	12
Vancomycin	12
Cefotaxime	11
Trimethoprim	11
Amoxicillin/clavulanic acid (Co-amoxiclav, co-amoxicillin)	10
Amikacin	9
Fosfomycin	8
Cefoxitin	7
Amoxicillin	6
Meropenem	6
Methicillin	6
Cefixime	5
Imipenem	5
Levofloxacin	4
Piperacillin/tazobactam	4
Tigecycline	4
Tobramycin	4
Cefuroxime	3
Colistin	3
Ertapenem	3
Tetracycline	3
Aztreonam	2
Cefalexin (Cephalexin)	2
Cefalotin	2
Cefepime	2
Chloramphenicol	2
Linezolid	2
Nalidixic acid	2
Norfloxacin	2
Ofloxacin	2
Penicillin	2
Piperacillin	2
Sulfamethoxazole	2
Teicoplanin	2
Ticarcillin	2
Benzylpenicillin	1
Cefazolin	1
Cefoperazone/sulbactam	1

Cefpodoxime	1
Clindamycin	1
Doripenem	1
Erythromycin	1
Moxifloxacin	1
Streptomycin	1

Diagnostic UTI technologies in high risk or special population groups

The technologies identified in this scan were primarily employed for the diagnosis of UTIs. A subset, however, was reported in studies involving patients with complicated or recurrent UTIs. For complicated cases, technologies such as DocLab UTM 2.0, Guidance UTI, and PCR methods were utilised. In recurrent cases, LEGENDplex Human Inflammation Panel 1, BioLegend-HU Th Cytokine Panels, PGE2 ELISA, and mNGS methods were employed.

A subset of products was reported as being used exclusively in paediatric patients. These included Human IL-6 and IL-8 ELISA Kits, Human sTLR4 ELISA Kit, Human sTLR5 ELISA Kit, Human IL-8 Platinum ELISA Kit, Illumina NextSeq 550, MALDI Biotyper, Piezoelectric electronic noses, Quantum Blue sCal onQuantum Blue reader, Siemens Dimension, Sysmex XN-1000. Additional methods reported in paediatric populations included urine dipsticks, 16S ribosomal RNA gene sequencing, CRP and systemic immune-inflammation index (SII), and a prediction model for early detection of drug-specific resistance.

Methods in earlier stages of development, such as Cation Dye-Triggered Gold Nanoparticle Electrokinetic Agglutination Analysis (CD-TEAA), customised LAMP panels, and a rapid immunochromatographic test for Escherichia coli detection, were reported to be used in both children and adults, along with products such as MALDI Biotyper and VITEK 2. One study also reported the use of qPCR for the diagnosis of lower UTI in women with chronic lower urinary tract symptoms.

Several studies further highlighted the presence of co-morbid conditions among patients undergoing diagnostic testing, including benign prostatic hyperplasia, bladder cancer, and a range of gynaecological conditions. Table 12 summarises co-morbid conditions reported alongside the diagnostic technologies employed.

Table 12. Technologies used in populations with comorbidities

Co-morbid condition	Name of technology/ies
Acute stone pyelonephritis	sTREM-1 assay- ELISA
Benign prostatic hyperplasia	BD Phoenix, BACTEC, VITEK 2 Compact
Bladder cancer	VITEK 2
Chronic lower urinary tract symptoms (LUTS)	qPCR
Kidney transplant	Human IL 17 ELISA Kit
Post kidney transplant	Metagenomic next-generation sequencing (mNGS)
Post menopausal	Electrofluidic capacitor-based biosensor for prostaglandin E2 detection, LEGENDplex Human Inflammation Panel 1, BioLegend-HU Th Cytokine Panels, PGE2 ELISA, USENSE platform
Pregnancy, type 1 diabetes	MultiPath analyzer
Spinal cord injury	Machine learning-based diagnostic framework
Vesicoureteral reflux	Illumina NextSeq 550

Implications and recommendations

The implications of emerging trends in UTI and AMR diagnostics were considered using the PESTLE framework, which enables a structured assessment of Political, Economic, Social, Technological, Legal, and Environmental dimensions. This approach highlights how broader system-level factors may influence the adoption, scalability, and impact of diagnostic innovations. By situating findings within this framework, we provide a balanced view of potential challenges and opportunities, which informs the recommendations outlined in this section.

Environmental:

The environmental dimension of AMR is increasingly recognised as critical,[17] due to the unregulated or inappropriate use of antibiotics, the antimicrobial resistance genes (ARGs) have become widespread including land surface and water bodies.[18] AMR affects countries in all regions and at all income levels. Its drivers and consequences are exacerbated by poverty and inequality, and low- and middle-income countries are most affected.[19] However, comprehensive and comparative monitoring of AMR in the environment—defined as all settings not directly linked to humans or domesticated animals, and not situated within indoor spaces normally inhabited by people—remains poorly established.[20] Environmental AMR has

direct implications for UTIs. A systematic review found AMR bacteria, including *Enterobacteriaceae*, detected at environmental sites relevant for human exposure—such as recreational waters, drinking water, fresh produce, and sources of wastewater and manure—indicating risk for exposure that could contribute to community-acquired infections like UTIs.[21]

Societal:

The Hospital Episode Statistics (HES) data for 2023-2024 in England highlighted that 189,756 hospital admissions related to UTI, resulting in a total of 1.2 million NHS bed-days.[22] Furthermore, people more likely to be hospitalised with UTI diagnosis are the elderly (over 70 years old) and women, with an increased time in hospital directly related to increased age.[22] However, the burden of UTIs is substantial, affecting individuals across all age groups, but with a markedly higher prevalence in women. For some, recurrent infections lead to ongoing symptoms that can significantly disrupt quality of life, impacting physical health, emotional wellbeing, and daily functioning.[23] Chronic UTI is a matter of concern at UK Parliament level recognising the urgent need for better care and treatment for chronic UTIs, highlights the wider neglect of women's health, and calls on the Government to invest in research, specialist services, and timely access to effective care.[24]

In older adults, UTIs are not only common but also particularly serious. They are strongly linked to episodes of delirium[25], increased frailty, and a reduced capacity to carry out essential activities of daily living, often resulting in loss of independence and greater reliance on health and social care.[26]

Studies involving patients with complicated or recurrent UTIs represent a minority amongst the records identified in this horizon scan. Perhaps due to these populations increased frailty or risk of further adverse events, studies that test diagnostic performance on these groups have been scarce. A more focussed search would be needed to identify if certain technologies are more likely to be used in chronic or recurrent UTIs in the elderly or women (peri-menopausal, pregnant, etc).

Economic:

The UK Health Security Agency (UKHSA) analysis of 'payment by results' data reveals that hospital admissions with UTIs as the primary diagnosis incurred costs of more than £604 million.[22] A 2024 published mathematical model developed to assess the costs and health

benefits of implementing a rapid susceptibility test for UTIs in secondary care settings in England estimated that the implementation of fast bacterial impedance cytometry test (BICT) would be cost-effective from the NHS healthcare system perspective. Our horizon scan has identified one test (iFAST by iFast Diagnostics, UK) that meets the criteria and has the potential to make cost-savings to the NHS if implemented in secondary care UTI testing.[27]

Technological:

The findings indicate that the majority of UTI diagnostic technologies are already highly mature, with most classified at TRL 9 and therefore market-ready. A substantial proportion of these are able to provide both pathogen identification and susceptibility testing, which is crucial for guiding antibiotic prescribing and improving antimicrobial stewardship. This suggests that the field is not constrained by a lack of available technologies but rather by the challenges of implementation, integration into clinical pathways, and widespread adoption.

At the same time, the analysis highlights a limited innovation pipeline. Only a limited number of technologies were identified at TRL 6–8 (28 in total of which only seven were products), and 18 methods and no products at TRL 5, suggesting that relatively few novel solutions are progressing through the intermediate stages of development toward clinical readiness. This raises concerns about the sustainability of innovation in the medium term, as the current dominance of TRL 9 technologies may translate into incremental improvements rather than transformative advances.

The relatively small number of market-ready biomarker-based (n=12 products and five methods) and point-of-care (POC) technologies n=9 products and n=7 methods) is also notable. Rapid, near-patient diagnostics are especially important for UTIs, where timely differentiation between bacterial causes and susceptibility patterns is critical. Addressing this gap could have a substantial impact on reducing unnecessary antibiotic use and improving early detection of resistant pathogens. Il-8 had prominently showed on our results indicating the exploratory research that is considering this biomarker as a potential new UTI biomarker due to its ability to differentiate inflammation due to UTI infection or due to other causative underlaying conditions. A recent i4i NIHR funded project explored the hypothesis of using IL-8 alone or in combination with another reactive protein, as a potential biomarker for UTI.[28,29]

For AMR detection, the strong presence of TRL 9 technologies capable of both identifying pathogens and determining susceptibility is encouraging, as these tools have immediate potential for clinical utility. However, the dominance on mature technologies also suggests that future improvements may be incremental unless more disruptive approaches (such as genomic, multiplex, or AI-enhanced diagnostics) are developed and translated into practice. As for AI and ML approaches our results indicate that the field is currently methodologically dominated, with most studies focusing on algorithm development rather than commercialised diagnostics; only two entries represent product-level implementations, indicating that translation into deployable technologies remains at an early stage.

Our scan presents some limitations. The scope of this scan, although broad, was geared to our stakeholders' needs for UTI technologies at late stage or mid-stage of development, other technologies might be in emerging horizon that have not been captured by our searches. Furthermore, we searched sources and regulatory agencies that align with the current UK health and care needs and regulations, this has limited our ability to search beyond the US, EU or UK into other countries such as China, Japan or Australia and New Zealand which may have yielded technologies in scope but not suitable for immediate decision-making in the UK due to their different regulatory pathways. We limited our searches to English language only and to research articles published since 2021, the last time a horizon scan on this topic was undertaken by the Innovation Observatory.[12] Some relevant technologies may have been missed if published in other languages or after the last search was conducted (June 2025).

Conclusion:

This horizon scan provides a cross-sectional overview of currently available and emerging UTI diagnostic technologies. It is not intended to replace a systematic review but to inform decision-makers of the existence and basic characteristics of these tools. While mature technologies capable of pathogen and susceptibility testing are already available and could be more widely deployed in the short term, the innovation pipeline remains limited. To ensure sustained progress, future investment should prioritise technologies that solve current system problems. Without such efforts, advances in UTI diagnostics and AMR detection risk plateauing, hindering effective responses to the global challenge of antimicrobial resistance.

Other information

Registration and protocol

The protocol for this project was agreed internally with our stakeholders and ahead of the start of this project. The protocol has not been published. Once the project commenced, no deviations from the protocol were undertaken.

Support

This study/project is funded by the National Institute for Health and Care Research (NIHR) [NIHR IO/project reference HSRIC-2016-10009]

Competing interests

The authors report no competing interests to declare.

Availability of data, code and other materials

With the agreement of our stakeholders, the data gathered while undertaking this horizon scan may be requested under reasonable circumstances.

Appendix A

Bibliographic database searches

Embase (Ovid)
Database(s): **Embase** 1974 to 2025 June 16 – Date of Search 17/06/2025
Search Strategy:

#	Searches	Results
1	(microbial antibiotic resistance or antimicrobial drug resistance* or antibiotic resistance or antibacterial drug resistance* or antibacterial resistance or antibiotic non?susceptibility or bacterial drug resistance* or bacterial resistance* or bacterium resistance* or microbial drug resistance or Antimicrobial resistance or Antifungal or Anti?Fungal or Fungicid* or Antifungic or Anti?fungic or antiseptic* or Anti?Infective or Biomarker or Biological Marker* or Molecular Marker or Signature Molecule* or Plasma concentration or Interleukin-6 or B-Cell Stimulatory Factor-2 or BSF-2 or Hepatocyte-Stimulating Factor or Hybridoma Growth Factor or IFN-beta 2 or IL-6 or IL6 or MGI-2 or Myeloid Differentiation-Inducing Protein or B Cell Stimulatory Factor-2 or B Cell Differentiation Factor or Interferon beta 2 or Hepatocyte stimulating factor or Plasmacytoma growth factor or Serious Bacterial Infections or SBIs or Escherichia coli or Bacterium coli or E coli or Enterococcus coli or Staphylococcus aureus or Staphylococcus pyogenes aureus or Micrococcus pyogenes or Micrococcus aureus or Staph aureus or Staphylococcus citreus or Klebsiella spp or Calymmatobacterium or Donovania or Hyalococcus or Acinetobacter spp or Streptococcus agalactiae or Streptococcus Group B or Group B streptococcus or Streptococcus difficilis or group b strep or b group streptococcus or strep agalactiae or Streptococcus pneumoniae or Diplococcus pneumoniae or Pneumococcus or Micrococcus pneumoniae or Pneumococcal or resistant organi?m* or carbapenemase producing bacteria or cytokines or Microbiom* or Clostridium difficile or Clostridioides difficile or C diff or superbugs or (Carbapenem-resistant and (enterobacterales or acinetobacter baumannii)) or Cephalosporin-resistant enterobacterales or (Fluoroquinolone-resistant and (salmonella typhi or shigella spp or non-typhoidal salmonella)) or (Methicillin-resistant and staphylococus aureus) or (Macrolide-resistant and (Group A streptococci or Streptococcus pneumoniae)) or (Ampicillin-resistant and Haemophilus influenzae) or (Penicillin-resistant and Group B Streptococci) or (MRSA or methicillin-resistant staphylococcus aureuseb) or carbapenem-resistant or Fluoroquinolone-resistant or Cephalosporin-resistant or Methicillin-resistant or Macrolide-resistant or Ampicillin-	1972294

	resistant or Penicillin-resistant or Bactericidal or Bacteriocides or Bactericides or Anti?Mycobacterial or antimycobacterial).ab,ti.	
2	*antibiotic resistance/ or *antifungal agent/ or *fungicide/ or *antiinfective agent/ or *biological marker/ or *molecular marker/ or *interleukin 6/ or *B lymphocyte differentiation factor/ or *alpha2b interferon/ or *bacterial infection/ or *Escherichia coli/ or *Staphylococcus aureus/ or *Klebsiella/ or *Streptococcus agalactiae/ or *group B streptococcal infection/ or *Streptococcus pneumoniae/ or *pneumococcal infection/ or *carbapenemase producing enterobacteriaceae/ or *cytokine/ or *microbiome/ or *Clostridioides difficile/ or *bactericidal activity/ or *bactericide/ or *antimycobacterial agent/	775415
3	1 or 2	2255754
4	(pyelonephritis or UTI or Cystitis or Cystitides or pyuria or Urocystitis or (Urinary tract adj3 (infected or infection or inflamed or infectious)) or (Bladder adj3 (infected or infection or inflamed or infectious))).ab,ti.	98203
5	*urinary tract infection/ or *urinary tract inflammation/ or *pyuria/ or *pyelonephritis/ or *cystitis/	55402
6	4 or 5	120252
7	(diagnos* or Diagnostic Accurac* or Diagnostic test accuracy or Accuracy of Diagnos* or accuracy diagnostic* or Detect* or Monitor* or identif* or recogni* or assess*).ab,ti.	17637069
8	*diagnosis/ or *diagnostic accuracy/ or *fungal detection/ or *bacterium detection/ or *monitoring/	131760
9	7 or 8	17651027
10	(((microbial antibiotic resistance or antimicrobial drug resistance* or antibiotic resistance or antibacterial drug resistance* or antibacterial resistance or antibiotic non?susceptibility or bacterial drug resistance* or bacterial resistance* or bacterium resistance* or microbial drug resistance or Antimicrobial resistance or Antifungal or Anti?Fungal or Fungicid* or Antifungic or Anti?fungic or antiseptic* or Anti?Infective or Biomarker or Biological Marker* or Molecular Marker or Signature Molecule* or Plasma concentration or Interleukin-6 or B-Cell Stimulatory Factor-2 or BSF-2 or Hepatocyte-Stimulating Factor or Hybridoma Growth Factor or IFN-beta 2 or IL-6 or IL6 or MGI-2 or Myeloid Differentiation-Inducing Protein or B Cell Stimulatory Factor-2 or B Cell Differentiation Factor or Interferon beta 2 or Hepatocyte stimulating factor or Plasmacytoma growth factor or Serious Bacterial Infections or SBIs or Escherichia coli or Bacterium coli or E coli or	9832

	Enterococcus coli or Staphylococcus aureus or Staphylococcus pyogenes aureus or Micrococcus pyogenes or Micrococcus aureus or Staph aureus or Staphylococcus citreus or Klebsiella spp or Calymmatobacterium or Donovania or Hyalococcus or Acinetobacter spp or Streptococcus agalactiae or Streptococcus Group B or Group B streptococcus or Streptococcus difficilis or group b strep or b group streptococcus or strep agalactiae or Streptococcus pneumoniae or Diplococcus pneumoniae or Pneumococcus or Micrococcus pneumoniae or Pneumococcal or resistant organi?m* or carbapenemase producing bacteria or cytokines or Microbiom* or Clostridium difficile or Clostridioides difficile or C diff or superbugs or (Carbapenem-resistant and (enterobacterales or acinetobacter baumannii)) or Cephalosporin-resistant enterobacterales or (Fluoroquinolone-resistant and (salmonella typhi or shigella spp or non-typhoidal salmonella)) or (Methicillin-resistant and staphylococus aureus) or (Macrolide-resistant and (Group A streptococci or Streptococcus pneumoniae)) or (Ampicillin-resistant and Haemophilus influenzae) or (Penicillin-resistant and Group B Streptococci) or (MRSA or methicillin-resistant staphylococcus aureuseb) or carbapenem-resistant or Fluoroquinolone-resistant or Cephalosporin-resistant or Methicillin-resistant or Macrolide-resistant or Ampicillin-resistant or Penicillin-resistant or Bactericidal or Bacteriocides or Bactericides or Anti?Mycobacterial or antimycobacterial).ab,ti. or (*antibiotic resistance/ or *antifungal agent/ or *fungicide/ or *antiinfective agent/ or *biological marker/ or *molecular marker/ or *interleukin 6/ or *B lymphocyte differentiation factor/ or *alpha2b interferon/ or *bacterial infection/ or *Escherichia coli/ or *Staphylococcus aureus/ or *Klebsiella/ or *Streptococcus agalactiae/ or *group B streptococcal infection/ or *Streptococcus pneumoniae/ or *pneumococcal infection/ or *carbapenemase producing enterobacteriaceae/ or *cytokine/ or *microbiome/ or *Clostridioides difficile/ or *bactericidal activity/ or *bactericide/ or *antimycobacterial agent/)) and ((pyelonephritis or UTI or Cystitis or Cystitides or pyuria or Urocystitis or (Urinary tract adj3 (infected or infection or inflamed or infectious)) or (Bladder adj3 (infected or infection or inflamed or infectious))).ab,ti. or (*urinary tract infection/ or *urinary tract inflammation/ or *pyuria/ or *pyelonephritis/ or *cystitis/))) adj4 ((diagnos* or Diagnostic Accurac* or Diagnostic test accuracy or Accuracy of Diagnos* or accuracy diagnostic* or Detect* or Monitor* or identif* or recogni* or assess*).ab,ti. or (*diagnosis/ or *diagnostic accuracy/ or *fungal detection/ or *bacterium detection/ or *monitoring/))	
11	(rat or rats or mouse or mice or swine or porcine or murine or sheep or lambs or pigs or piglets or rabbit or rabbits or cat or cats or dog or dogs or cattle or bovine or monkey or monkeys or trout or marmoset$1).ti. and animal experiment/	1305463

12	animal experiment/ not (human experiment/ or human/)	2753587
13	11 or 12	2835977
14	(systematic review or meta-analysis).pt.	0
15	meta-analysis/ or systematic review/ or systematic reviews as topic/ or meta-analysis as topic/ or "meta analysis (topic)"/ or "systematic review (topic)"/ or exp technology assessment, biomedical/ or network meta-analysis/	764669
16	((systematic* adj3 (review* or overview*)) or (methodologic* adj3 (review* or overview*))).ti,ab,kf.	504780
17	((quantitative adj3 (review* or overview* or synthes*)) or (research adj3 (integrati* or overview*))).ti,ab,kf.	22915
18	((integrative adj3 (review* or overview*)) or (collaborative adj3 (review* or overview*)) or (pool* adj3 analy*)).ti,ab,kf.	65687
19	(data synthes* or data extraction* or data abstraction*).ti,ab,kf.	62760
20	(handsearch* or hand search*).ti,ab,kf.	14660
21	(mantel haenszel or peto or der simonian or dersimonian or fixed effect* or latin square*).ti,ab,kf.	55280
22	(met analy* or metanaly* or technology assessment* or HTA or HTAs or technology overview* or technology appraisal*).ti,ab,kf.	24459
23	(meta regression* or metaregression*).ti,ab,kf.	22590
24	(meta-analy* or metaanaly* or systematic review* or biomedical technology assessment* or bio-medical technology assessment*).mp,hw.	901462
25	(medline or cochrane or pubmed or medlars or embase or cinahl).ti,ab,hw.	556243
26	(cochrane or (health adj2 technology assessment) or evidence report).jw.	32844
27	(comparative adj3 (efficacy or effectiveness)).ti,ab,kf.	33031

28	(outcomes research or relative effectiveness).ti,ab,kf.	18459
29	((indirect or indirect treatment or mixed-treatment or bayesian) adj3 comparison*).ti,ab,kf.	8829
30	(multi* adj3 treatment adj3 comparison*).ti,ab,kf.	481
31	(mixed adj3 treatment adj3 (meta-analy* or metaanaly*)).ti,ab,kf.	267
32	umbrella review*.ti,ab,kf.	2949
33	(multi* adj2 paramet* adj2 evidence adj2 synthesis).ti,ab,kf.	37
34	(multiparamet* adj2 evidence adj2 synthesis).ti,ab,kf.	22
35	(multi-paramet* adj2 evidence adj2 synthesis).ti,ab,kf.	31
36	or/14-35	1203560
37	retrospective study/ or case report/ or exp case control study/	5137863
38	((retrospective adj7 (study or studies or design or analysis or analyses or data or review)) or ((case adj3 (report or reports or study or studies or histories)) or ((case adj control) or (case adj comparison) or (case adj controlled) or (case-referent adj3 (study or studies or design or analysis or analyses))))).ti,ab,kf.	2757723
39	37 or 38	5788287
40	13 or 36 or 39	9663128
41	10 not 40	6741
42	limit 41 to english language	5970

43	limit 42 to yr="2021 -Current"	1676

Cochrane Library
Cochrane library – Date of Search 17/06/2025

ID Search Hits

#1 (((microbial antibiotic resistance or antimicrobial drug resistance* or antibiotic resistance or antibacterial drug resistance* or antibacterial resistance or antibiotic non?susceptibility or bacterial drug resistance* or bacterial resistance* or bacterium resistance* or microbial drug resistance or Antimicrobial resistance or Antifungal or Anti?Fungal or Fungicid* or Antifungic or Anti?fungic or antiseptic* or Anti?Infective or Biomarker or Biological Marker* or Molecular Marker or Signature Molecule* or Plasma concentration or Interleukin-6 or B-Cell Stimulatory Factor-2 or BSF-2 or Hepatocyte-Stimulating Factor or Hybridoma Growth Factor or IFN-beta 2 or IL-6 or IL6 or MGI-2 or Myeloid Differentiation-Inducing Protein or B Cell Stimulatory Factor-2 or B Cell Differentiation Factor or Interferon beta 2 or Hepatocyte stimulating factor or Plasmacytoma growth factor or Serious Bacterial Infections or SBIs or Escherichia coli or Bacterium coli or E coli or Enterococcus coli or Staphylococcus aureus or Staphylococcus pyogenes aureus or Micrococcus pyogenes or Micrococcus aureus or Staph aureus or Staphylococcus citreus or Klebsiella spp or Calymmatobacterium or Donovania or Hyalococcus or Acinetobacter spp or Streptococcus agalactiae or Streptococcus Group B or Group B streptococcus or Streptococcus difficilis or group b strep or b group streptococcus or strep agalactiae or Streptococcus pneumoniae or Diplococcus pneumoniae or Pneumococcus or Micrococcus pneumoniae or Pneumococcal or resistant organi?m* or carbapenemase producing bacteria or cytokines or Microbiom* or Clostridium difficile or Clostridioides difficile or C diff or superbugs or (Carbapenem-resistant and (enterobacterales or acinetobacter baumannii)) or Cephalosporin-resistant enterobacterales or (Fluoroquinolone-resistant and (salmonella typhi or shigella spp or non-typhoidal salmonella)) or (Methicillin-resistant and staphylococus aureus) or (Macrolide-resistant and (Group A streptococci or Streptococcus pneumoniae)) or (Ampicillin-resistant and Haemophilus influenzae) or (Penicillin-resistant and Group B Streptococci) or (MRSA or methicillin-resistant staphylococcus aureuseb) or carbapenem-resistant or Fluoroquinolone-resistant or Cephalosporin-resistant or Methicillin-resistant or Macrolide-resistant or Ampicillin-resistant or Penicillin-resistant or Bactericidal or Bacteriocides or Bactericides or Anti?Mycobacterial or antimycobacterial))):ti,ab,kw (Word variations have been searched) 187874

#2 MeSH descriptor: [Drug Resistance, Microbial] this term only 925

#3 MeSH descriptor: [Antifungal Agents] this term only 2286

#4 MeSH descriptor: [Anti-Infective Agents] this term only 3243

#5 MeSH descriptor: [Biomarkers] this term only 21149

#6 MeSH descriptor: [Interleukin-6] this term only 4380

#7 MeSH descriptor: [Interferon alpha-2] this term only1922

#8 MeSH descriptor: [Bacterial Infections] this term only 3720

#9 MeSH descriptor: [Escherichia coli] this term only 908

#10 MeSH descriptor: [Pneumonia, Staphylococcal] this term only 43

#11 MeSH descriptor: [Klebsiella] this term only 68

#12 MeSH descriptor: [Streptococcus agalactiae] this term only 148

#13 MeSH descriptor: [Streptococcal Infections] this term only 760

#14 MeSH descriptor: [Streptococcus pneumoniae] this term only 779

#15 MeSH descriptor: [Pneumococcal Infections] this term only 806

#16 MeSH descriptor: [Carbapenem-Resistant Enterobacteriaceae] this term only 15

#17 MeSH descriptor: [Cytokines] this term only 4567

#18 MeSH descriptor: [Microbiota] this term only 645

#19 MeSH descriptor: [Clostridioides difficile] this term only 306

#20 MeSH descriptor: [Anti-Bacterial Agents] this term only 15258

#21 #1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 200070

#22 ((pyelonephritis or UTI or Cystitis or Cystitides or pyuria or Urocystitis or (Urinary tract adj3 (infected or infection or inflamed or infectious)) or (Bladder adj3 (infected or infection or inflamed or infectious)))):ti,ab,kw (Word variations have been searched) 5504

#23 MeSH descriptor: [Urinary Tract Infections] this term only 2853

#24 MeSH descriptor: [Pyelonephritis] this term only 310

#25 MeSH descriptor: [Pyuria] this term only 43

#26 MeSH descriptor: [Cystitis] this term only 448

#27 #22 or #23 or #24 or #25 or #26 7167

#28 ((diagnos* or Diagnostic Accurac* or Diagnostic test accuracy or Accuracy of Diagnos* or accuracy diagnostic* or Detect* or Monitor* or identif* or recogni* or assess*):ti (Word variations have been searched)):ti,ab,kw (Word variations have been searched) 98071

#29 MeSH descriptor: [Diagnosis] this term only 80

#30 #28 or #29 98112

#31 #21 and #27 and #30 with Publication Year from 2021 to 2025, in Trials 22

#32 #31 AND journal:pt 12

IEEEXplorer
Date of Search 17/06/2025

Showing **1-19** of **19** results for

(("Publication Title":"microbial antibiotic resistance" OR "antimicrobial drug resistance" OR "antibiotic resistance" OR "antibacterial drug resistance" OR "antibacterial resistance" OR "antibiotic non?susceptibility" OR "bacterial drug resistance" OR "bacterial resistance" OR "bacterium resistance" OR "microbial drug resistance" OR "Antimicrobial resistance" OR "Antifungal" OR "Anti Fungal" OR "Fungicidal" OR "Antifungic" OR "Anti fungic" OR "antiseptic" OR "Anti Infective" OR "Biomarker" OR "Biological Marker" OR "Molecular Marker" OR "Signature Molecule" OR "Plasma concentration" OR "Interleukin-6" OR "B-Cell Stimulatory Factor-2" OR "BSF-2" OR "Hepatocyte-Stimulating Factor" OR "Hybridoma Growth Factor" OR "IFN-beta 2" OR "IL-6" OR "IL6" OR "MGI-2" OR "Myeloid Differentiation-Inducing Protein" OR "B Cell Stimulatory Factor-2" OR "B Cell Differentiation Factor" OR "Interferon beta 2" OR "Hepatocyte stimulating factor" OR "Plasmacytoma growth factor" OR "Serious Bacterial Infections" OR "SBIs" OR "Escherichia coli" OR "Bacterium coli" OR "E coli" OR "Enterococcus coli" OR "Staphylococcus aureus" OR "Staphylococcus pyogenes aureus" OR "Micrococcus pyogenes" OR "Micrococcus aureus" OR "Staph aureus" OR "Staphylococcus citreus" OR "Klebsiella spp" OR "Calymmatobacterium" OR "Donovania" OR "Hyalococcus" OR "Acinetobacter spp" OR "Streptococcus agalactiae" OR "Streptococcus Group B" OR "Group B streptococcus" OR "Streptococcus difficilis" OR "group b strep" OR "b group streptococcus" OR "strep agalactiae" OR "Streptococcus pneumoniae" OR "Diplococcus pneumoniae" OR "Pneumococcus" OR "Micrococcus pneumoniae" OR "Pneumococcal" OR "resistant organism" OR "carbapenemase producing bacteria" OR "cytokines" OR "Microbiom*" OR "Clostridium difficile" OR "Clostridioides difficile" OR "C diff" OR "superbugs" OR "Abstract":"microbial antibiotic resistance" OR "antimicrobial drug resistance" OR "antibiotic resistance" OR "antibacterial drug resistance" OR "antibacterial resistance" OR "antibiotic non?susceptibility" OR "bacterial drug resistance" OR "bacterial resistance" OR "bacterium resistance" OR "microbial drug resistance" OR "Antimicrobial resistance" OR "Antifungal" OR "Anti Fungal" OR "Fungicidal" OR "Antifungic" OR "Anti fungic" OR "antiseptic" OR "Anti Infective" OR "Biomarker" OR "Biological Marker" OR "Molecular Marker" OR "Signature Molecule" OR "Plasma concentration" OR "Interleukin-6" OR "B-Cell Stimulatory Factor-2" OR "BSF-2" OR "Hepatocyte-Stimulating Factor" OR "Hybridoma Growth Factor" OR "IFN-beta 2" OR "IL-6" OR "IL6" OR "MGI-2" OR "Myeloid Differentiation-Inducing Protein" OR "B Cell Stimulatory Factor-2" OR "B Cell Differentiation Factor" OR "Interferon beta 2" OR "Hepatocyte stimulating factor" OR "Plasmacytoma growth factor" OR "Serious Bacterial Infections" OR "SBIs" OR "Escherichia coli" OR "Bacterium coli" OR "E coli" OR "Enterococcus coli" OR "Staphylococcus aureus" OR "Staphylococcus pyogenes aureus" OR "Micrococcus pyogenes" OR "Micrococcus aureus" OR "Staph aureus" OR "Staphylococcus citreus" OR "Klebsiella spp" OR "Calymmatobacterium" OR "Donovania" OR "Hyalococcus" OR

"Acinetobacter spp" OR "Streptococcus agalactiae" OR "Streptococcus Group B" OR "Group B streptococcus" OR "Streptococcus difficilis" OR "group b strep" OR "b group streptococcus" OR "strep agalactiae" OR "Streptococcus pneumoniae" OR "Diplococcus pneumoniae" OR "Pneumococcus" OR "Micrococcus pneumoniae" OR "Pneumococcal" OR "resistant organism" OR "carbapenemase producing bacteria" OR "cytokines" OR "Microbiom*" OR "Clostridium difficile" OR "Clostridioides difficile" OR "C diff" OR "superbugs") AND ("Publication Title":"pyelonephritis" OR "UTI" OR "Cystitis" OR "Cystitides" OR "pyuria" OR "Urocystitis" OR "Urinary tract infected" OR "Urinary tract infection" OR "Urinary tract inflamed" OR "Urinary tract infectious" OR "Bladder infected" OR "bladder infection" OR "bladder inflamed" OR "bladder infectious" OR "Abstract":"pyelonephritis" OR "UTI" OR "Cystitis" OR "Cystitides" OR "pyuria" OR "Urocystitis" OR "Urinary tract infected" OR "Urinary tract infection" OR "Urinary tract inflamed" OR "Urinary tract infectious" OR "Bladder infected" OR "bladder infection" OR "bladder inflamed" OR "bladder infectious") AND ("Publication Title":"diagnosis" OR "Diagnostic Accuracy" OR "Diagnostic test accuracy" OR "Accuracy of Diagnostic" OR "accuracy diagnostic" OR "Detect" OR "Monitor" OR "identification" OR "recognise" OR "assess" OR "Abstract":"diagnosis" OR "Diagnostic Accuracy" OR "Diagnostic test accuracy" OR "Accuracy of Diagnostic" OR "accuracy diagnostic" OR "Detect" OR "Monitor" OR "identification" OR "recognise" OR "assess"))

Filters Applied:

2021 - 2025

Clinical trial databases

Clinical Trial.gov – Date of Search 17/06/2025
URL: https://clinicaltrials.gov/

Viewing 1-10 out of 12 studies

Showing results for: ("microbial antibiotic resistance" OR "antimicrobial drug resistance*" OR "antibiotic resistance" OR "antibacterial drug resistance*" OR "antibacterial resistance" OR "antibiotic non?susceptibility" OR "bacterial drug resistance*" OR "bacterial resistance*" OR "bacterium resistance*" OR "microbial drug resistance" OR "Antimicrobial resistance" OR "Antifungal" OR "Anti?Fungal" OR "Fungicid*" OR "Antifungic" OR "Anti?fungic" OR "antiseptic*" OR "Anti?Infective" OR "Biomarker" OR "Biological Marker*" OR "Molecular Marker" OR "Signature Molecule*" OR "Plasma concentration" OR "Interleukin-6" OR "B-Cell Stimulatory Factor-2" OR "BSF-2" OR "Hepatocyte-Stimulating Factor" OR "Hybridoma Growth Factor" OR "IFN-beta 2" OR "IL-6" OR "IL6" OR "MGI-2" OR "Myeloid Differentiation-Inducing Protein" OR "B Cell Stimulatory Factor-2" OR "B Cell Differentiation Factor" OR "Interferon beta 2" OR "Hepatocyte stimulating factor" OR "Plasmacytoma growth factor" OR "Serious Bacterial Infections" OR "SBIs" OR "Escherichia coli" OR "Bacterium coli" OR "E coli" OR "Enterococcus coli" OR "Staphylococcus aureus" OR "Staphylococcus pyogenes aureus" OR "Micrococcus pyogenes" OR "Micrococcus aureus" OR "Staph aureus" OR "Staphylococcus citreus" OR "Klebsiella spp" OR "Calymmatobacterium" OR "Donovania" OR "Hyalococcus" OR "Acinetobacter spp" OR "Streptococcus agalactiae" OR "Streptococcus Group B" OR "Group B streptococcus" OR

"Streptococcus difficilis" OR "group b strep" OR "b group streptococcus" OR "strep agalactiae" OR "Streptococcus pneumoniae" OR "Diplococcus pneumoniae" OR "Pneumococcus" OR "Micrococcus pneumoniae" OR "Pneumococcal" OR "resistant organi?m*" OR "carbapenemase producing bacteria" OR "cytokines" OR "Microbiom*" OR "Clostridium difficile" OR "Clostridioides difficile" OR "C diff" OR "superbugs") AND ("pyelonephritis" OR "UTI" OR "Cystitis" OR "Cystitides" OR "pyuria" OR "Urocystitis" OR "Urinary tract infected" OR "Urinary tract infection" OR "Urinary tract inflamed" OR "Urinary tract infectious" OR "Bladder infected" OR "bladder infection" OR "bladder inflamed" OR "bladder infectious") | ("diagnos*" OR "Diagnostic Accurac*" OR "Diagnostic test accuracy" OR "Accuracy of Diagnos*" OR "accuracy diagnostic*" OR "Detect*" OR "Monitor*" OR "identif*" OR "recogni*" OR "assess*") | Study start on or after 01/02/2021

WHO clinical trial registry
URL: https://trialsearch.who.int/AdvSearch.aspx

Date of Search 17/06/2025

4 Trial Records

(("microbial antibiotic resistance" OR "antimicrobial drug resistance" OR "antibiotic resistance" OR "antibacterial drug resistance" OR "antibacterial resistance" OR "antibiotic non?susceptibility" OR "bacterial drug resistance" OR "bacterial resistance" OR "bacterium resistance" OR "microbial drug resistance" OR "Antimicrobial resistance" OR "Antifungal" OR "Anti Fungal" OR "Fungicidal" OR "Antifungic" OR "Anti fungic" OR "antiseptic" OR "Anti Infective" OR "Biomarker" OR "Biological Marker" OR "Molecular Marker" OR "Signature Molecule" OR "Plasma concentration" OR "Interleukin-6" OR "B-Cell Stimulatory Factor-2" OR "BSF-2" OR "Hepatocyte-Stimulating Factor" OR "Hybridoma Growth Factor" OR "IFN-beta 2" OR "IL-6" OR "IL6" OR "MGI-2" OR "Myeloid Differentiation-Inducing Protein" OR "B Cell Stimulatory Factor-2" OR "B Cell Differentiation Factor" OR "Interferon beta 2" OR "Hepatocyte stimulating factor" OR "Plasmacytoma growth factor" OR "Serious Bacterial Infections" OR "SBIs" OR "Escherichia coli" OR "Bacterium coli" OR "E coli" OR "Enterococcus coli" OR "Staphylococcus aureus" OR "Staphylococcus pyogenes aureus" OR "Micrococcus pyogenes" OR "Micrococcus aureus" OR "Staph aureus" OR "Staphylococcus citreus" OR "Klebsiella spp" OR "Calymmatobacterium" OR "Donovania" OR "Hyalococcus" OR "Acinetobacter spp" OR "Streptococcus agalactiae" OR "Streptococcus Group B" OR "Group B streptococcus" OR "Streptococcus difficilis" OR "group b strep" OR "b group streptococcus" OR "strep agalactiae" OR "Streptococcus pneumoniae" OR "Diplococcus pneumoniae" OR "Pneumococcus" OR "Micrococcus pneumoniae" OR "Pneumococcal" OR "resistant organism" OR "carbapenemase producing bacteria" OR "cytokines" OR "Microbiom*" OR "Clostridium difficile" OR "Clostridioides difficile" OR "C diff" OR "superbugs") AND ("pyelonephritis" OR "UTI" OR "Cystitis" OR "Cystitides" OR "pyuria" OR "Urocystitis" OR "Urinary tract infected" OR "Urinary tract infection" OR "Urinary tract inflamed" OR "Urinary tract infectious" OR "Bladder infected" OR "bladder infection" OR "bladder inflamed" OR "bladder infectious") AND ("diagnosis" OR "Diagnostic Accuracy" OR "Diagnostic test accuracy" OR "Accuracy of Diagnostic" OR "accuracy diagnostic" OR "Detect" OR "Monitor" OR "identification" OR "recognise" OR "assess")) Filter 2021 to 2025

Regulatory databases

FDA databases

The searches involved conducting a structured horizon scan for UTI-related medical devices using three FDA databases: the 510(k) Premarket Notification database, the De Novo database, and the Devices@FDA portal. For each source, the search was limited to devices reviewed between January 1, 2024, and the current date of search. In both the 510(k) and De Novo databases, the "Microbiology" panel was selected from the dropdown menu, and the decision date fields reflected the specified date range. Search results were first screened for relevance to UTI-related technologies directly on the website interface. After sifting the results on screen to identify those relevant to UTIs, the relevant records were manually annotated into our list of included technologies.

The Devices@FDA database portal was searched using a series of UTI-related terms: "Urinary tract infection," "UTI," "Bladder infection," "Kidney infection," "Cystitis," "Pyelonephritis," "Urinary microbial infection," "Complicated UTI," "Recurrent UTI," and "Catheter-associated UTI." Each term was searched independently within the same date range. For each term, the numbers of total and relevant records were logged in an Excel document, with corresponding results saved in the same results folder.

MHRA PADR Database

URL: https://pard.mhra.gov.uk/manufacturer-search/

A search by name of manufacturer or MHRA reference number (if available) was used to cross check the MHRA UK regulatory status of the identified technologies. Whenever available, results from this search were inputted into the data extraction form and used for analyses.

Technology appraisals and guidelines databases

NICE Health Technology Appraisal database

URL: https://www.nice.org.uk/guidance/published

The search for NICE Health Technology Appraisals was conducted on the NICE website under the "Published Guidance" tab, applying a date filter from 01/01/2021 to the present. The search was restricted to documents classified as "Guidance" and further narrowed by selecting "Diagnostics Guidance" and "Medical Technologies Guidance" under the Guidance Programme filter. The number of retrieved records was recorded and, where possible, results were copied

to the clipboard and pasted into a blank Excel file, preserving column structure and count integrity. The resulting spreadsheet was saved in the designated search folder.

The process was repeated for additional guidance categories listed in the top navigation tabs — namely "In Consultation," "In Development," and "Awaiting Development" — with the same filters applied. The results from each category were transferred to separate tabs within the Excel workbook and saved for further assessment and review.

NIHR HTA Library
URL: https://www.journalslibrary.nihr.ac.uk/hta#nav-archive

The latest five volumes, covering the years 2021 to 2025, were selected and screened by title. For each year, the total number of results was annotated and recorded in the search report. As the platform did not support exporting or downloading, all screening was conducted manually on screen. Titles of HTA publications were reviewed, and hyperlinks were followed where necessary to access the full documents.

HTA Database (Inahta)
URL: https://database.inahta.org/

Year filters (2021–2025) and the English language filter were applied, along with selecting all five available publication types. Due to limitations in the advanced search function, the simple search field was used. Separate searches were run for the following terms: *Urinary tract infection*, *UTI*, *Bladder infection*, *Kidney infection*, *AMR*, *Antimicrobial resistance*, *Bacterial infection*, *Urinary microbial infection*, *and Cystitis*.

Before each new search, filters were reset by clicking the database logo to avoid technical issues. Records with titles in square brackets—indicating non-English language—were excluded.

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