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## Establishing bacteriology laboratories in low-resource settings

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### Laboratory tools from the Fleming Fund antimicrobial resistance surveillance programme

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#### Abstract

**Problem** Current laboratory assessment tools aimed at improving bacteriology and testing for antimicrobial resistance focus on quality of laboratory services. No guidance exists for establishing bacteriology services necessary for diagnosis and surveillance of antimicrobial resistance in low- and middle-income countries.

**Approach** Comprehensive laboratory needs assessment tools and procurement catalogues were developed, piloted and used by the Fleming Fund programme. These tools were designed to support the strengthening of bacteriology testing capacity within national antimicrobial resistance surveillance systems receiving Fleming Fund support.

**Setting** The tools were used in reference laboratories and surveillance sites for antimicrobial resistance in 24 countries in the African, South-East Asia and Western Pacific regions, comprising 341 clinical, veterinary, aquaculture, food safety and environmental laboratories.

**Relevant changes** The needs assessment tool provides a structured framework for laboratory renovation and installation of bacteriology testing equipment. The procurement catalogues list reagents and consumables for antimicrobial resistance surveillance of priority pathogens in humans in the World Health Organization Global Antimicrobial Resistance and

Use Surveillance System and selected bacteria in terrestrial and aquatic food-producing animals. Combined with training and capacity-building initiatives supported through other Fleming Fund investments, these efforts have substantially enhanced diagnostic capacity for bacterial infections and antimicrobial resistance surveillance in the laboratories.

**Lessons learnt** These tools were instrumental in identifying gaps to enhance bacteriology laboratory capacity and capabilities and became an essential resource for procurement, tracking supplies and asset management. The tools are adaptable and can strengthen laboratory capacity in settings and health programmes beyond bacteriology and antimicrobial resistance surveillance.

## Introduction

Clinical bacteriology testing capacity and capability in resource-constrained settings are needed for accurate diagnosis and treatment of bacterial infections, effective antimicrobial stewardship activities and data collection for surveillance of antimicrobial resistance.<sup>1</sup> However, a recent study in sub-Saharan Africa showed important gaps in coverage, volume and quality of bacteriology testing. Only 1.3% (675/53770) of clinical laboratories in 14 countries provided bacteriology testing,<sup>2</sup> with only 393 facilities undertaking antimicrobial susceptibility testing and 66.9% (263/393) of these facilities performing fewer than 1000 tests for antimicrobial susceptibility a year. The World Health Organization's (WHO's) people-centred approach<sup>3</sup> emphasize diagnostic coverage and capabilities for bacterial and fungal pathogens as a priority.

Laboratory assessment tools are often used to support laboratories in resource-constrained settings in improving their capacity and capability. In bacteriology, these tools include the United States Centers for Disease Control and Prevention Laboratory Assessment of Antibiotic Resistance Testing Capacity<sup>4</sup> and the Foundation for Innovative New Diagnostics antimicrobial resistance scorecards.<sup>5</sup> These tools are designed for use in established laboratories where basic capability is already in place and the quality of testing needs to be assessed. Little guidance is available for ministries of health, agriculture and environment on establishing basic bacteriology services in low- and middle-income countries where these diagnostic services are lacking.

Since 2017, the Fleming Fund has supported countries to develop systems for antimicrobial resistance surveillance. A large proportion of funds is used for laboratory development and improvement including renovation, refurbishment, equipment and consumables for bacteriological diagnostics. This support is offered across the One Health disciplines of human health, veterinary, food safety and environmental microbiology laboratories.

To ensure consistent support for laboratories, the Fleming Fund Management Agent developed a laboratory needs assessment tool to evaluate the infrastructure and equipment required to provide effective and safe bacteriology services. Concurrently, procurement catalogues for key reagents and consumables were developed focusing on the WHO Global Antimicrobial Resistance

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and Use Surveillance System (GLASS) priority pathogens list<sup>6</sup> and indicator pathogens in poultry.<sup>7</sup>  
This paper outlines the main components of a laboratory needs assessment tool and the procurement catalogues developed by the Fleming Fund and the lessons learnt during deployment.

## Local settings

The tools were used in antimicrobial resistance reference laboratories and surveillance site laboratories in 24 Fleming Fund-supported countries in the African, South-East Asia and the Western Pacific regions. By the end of the programme 341 clinical, veterinary, aquaculture, food safety and environmental laboratories had used the tool. In the human health sector, sites provided diagnostic services to health facilities, where veterinary sites were primarily for conducting active surveillance activities.

## Approach

The Fleming Fund Management Agent developed a pilot tool in 2017 to assess infrastructure, utilities, equipment and consumable requirements for a basic bacteriology laboratory that can perform bacterial isolation and identification of non-fastidious pathogens from blood and urine samples and antimicrobial susceptibility testing by disc diffusion testing.<sup>8</sup> The tool was designed to be completed by laboratory assessors from the Fleming Fund Management Agent alongside staff from the recipient laboratory. The tool was piloted in Ghana, Lao People's Democratic Republic Nepal and Uganda, in 28 human health and 13 animal health laboratories.

Based on the pilot, the tool was modified to align more closely with the WHO *Global Antimicrobial Resistance Surveillance System: manual for early implementation*<sup>9</sup> and the London School of Tropical Medicine & Hygiene roadmap for participation in GLASS.<sup>8</sup> The sections modified were on biosafety and biosecurity, waste management, power and water, fixtures, equipment (including the working status and maintenance), consumables, information technology and data management, quality management, and clinical liaison and reporting. The tool included a mechanism to estimate the requirements for equipment and instruments based on actual or projected throughput of specimens at each site.

Further versions of the tool were developed during ongoing programme implementation, particularly to address basic structural requirements (e.g. doors, windows and flooring), with the latest tool published in 2025.<sup>10</sup> Each of the following subsections describes one part of the assessment tool.

## Premises assessment

The laboratory needs assessment tool provides a structured framework for evaluating the needs of a laboratory facility to ensure a safe and secure testing environment. The assessment covers all aspects

of the physical laboratory environment including work areas, benches, walls, ceilings, floors, doors, windows and climate control. Dedicated rooms, such as media preparation and autopsy rooms in veterinary facilities, are also assessed (Fig. 1). Rooms not directly related to laboratory work are excluded from the assessment (e.g. common areas of the laboratories). Major renovations (e.g. construction of new buildings or substantial internal changes to layout) are not included in the tool as this type of major building work is not undertaken by the Fleming Fund.

Trained evaluators assess the adequacy of laboratory space based on current and projected testing volumes and staffing levels. The tool also collects information on the facility's biosafety and biosecurity infrastructure. The tool is not intended to replace a comprehensive risk assessment as recommended by WHO;<sup>11</sup> rather, it helps identify the equipment needed to handle routine clinical specimens at biosafety level 2.

### **Utilities assessment**

The tool include assessments of essential but often overlooked laboratory utilities, particularly electricity and water systems. The tool assesses the presence of an adequate and stable electricity supply to support general laboratory equipment and analysers, including uninterruptible power supply back-up power in the event of a mains outage.

The supply of high-quality water to meet bacteriology testing standards is also assessed. Acknowledging that infrastructure needs vary by facility, the tool is intentionally adaptable, with a recommendation for a formal electrical survey and further specialist assessment where the minimum standard is not met. This recommendation ensures renovation plans are technically sound, context-specific, and budgeted appropriately, supporting sustainable improvements aligned with each facility's operational needs and country specification.

### **Equipment list**

The tool assesses general laboratory apparatus essential for: (i) preparing quality-assured media; (ii) culturing and isolating bacterial pathogens; (iii) performing antimicrobial susceptibility testing; and (iv) storing reagents and culture isolates. Equipment for data management, analysis and communication of surveillance and hospital data is also assessed. The list is similar to previous equipment lists<sup>12</sup> but emphasizes the importance of maintenance and calibration contract services for general laboratory equipment, including biosafety cabinets, incubators and autoclaves. The minimum standard, in line with the WHO GLASS programme, is a capability for blood culture (preferably using an automated system) and urine culture, with antimicrobial susceptibility testing performed by disc diffusion. Higher throughput, well-resourced laboratories or national laboratories were also assessed for suitability for advanced systems such as automated antimicrobial susceptibility testing

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platforms and matrix-assisted laser desorption ionization time-of-flight mass spectrometry for organism identification.

### **Summary of needs**

All responses that identify a specific need are automatically compiled into a summary page, which serves as the basis for developing a costed site plan. The tool also provides technical specifications of the different items and their intended use to streamline the procurement process.

### **Procurement catalogues**

To further assist in strengthening surveillance of antimicrobial resistance, standardized procurement catalogues of reagents and key consumables were developed for both the human health<sup>13</sup> and the veterinary sector.<sup>14</sup> The catalogues are organized into sections covering general culture media, essential chemical reagents, standard biochemical reagents and kits for bacterial identification, and reagents specific for antimicrobial susceptibility testing. For the veterinary sector, the catalogue includes a section on consumables for sample collection.

Since a standard catalogue cannot cover every testing possibility, the reagents proposed are recommendations based on key guiding principles. First, wherever possible, the tests included are simple, affordable and suitable for resource-constrained settings. Second, most reagents should be accessible from local distributors, as sustainable sourcing is a recurrent problem in low- and middle-income countries.<sup>1</sup> Third, the UK Standards for Microbiology Investigations<sup>15</sup> was the main reference to ensure alignment with recognized guidelines. Fourth, the catalogues cover the list of GLASS priority pathogens for the human health sector<sup>6</sup> and *Escherichia coli*, *Salmonella*, *Campylobacter* and *Enterococcus* for the veterinary sector.<sup>7</sup> The catalogues have been kept up to date with newer lists of priority organisms (e.g. from WHO GLASS). These procurement catalogues also allowed for diagnosis of locally important bacterial pathogens not covered by the GLASS pathogen priority list.

### **Relevant changes**

The laboratory needs assessment tool and procurement catalogues identified important gaps in laboratory capacity in microbiology services at 341 supported sites. The tool provided a list of essential equipment along with the modifications required to install and operate them as part of a robust and resilient laboratory system. The planning tool provided the basis for resource allocation for laboratory strengthening across the Fleming Fund programme, supporting important improvements in surveillance of antimicrobial resistance.

In some countries, assessments using the tool highlighted significant gaps in technical microbiology knowledge. As a result, targeted capacity-building initiatives were arranged by

Fleming Fund grantees, with experts providing training in both basic and advanced microbiology diagnostics.

## Lessons learnt

Box 1 provides a summary of the main lessons learnt to using the laboratory needs assessment tool and procurement catalogues. Challenges included language barriers between site personnel and external stakeholders (including engineers, procurement teams and regional programme staff), administrative hurdles in organizing site visits and limited time to cover the wide range of topics in the tool. The detailed requirements of bacteriology assessments meant that a single facility typically required at least a full day and a team of laboratory experts, possibly including a biomedical engineer. Sharing the tools with laboratory managers in advance proved most effective, enabling them to prepare beforehand. The catalogues provided a list of critical reagents and consumables but more accurate quantification would help forecast testing volumes and cost.

The laboratory needs assessment tool can be adapted for use in other laboratory evaluations beyond those of the Fleming Fund, and is a demonstrably versatile resource for strengthening laboratory and surveillance systems. The procurement catalogues were invaluable resources serving as the first comprehensive and accessible guide to microbiology reagents and key consumables for many users in resource-constrained settings.

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## Competing interests:

None declared.

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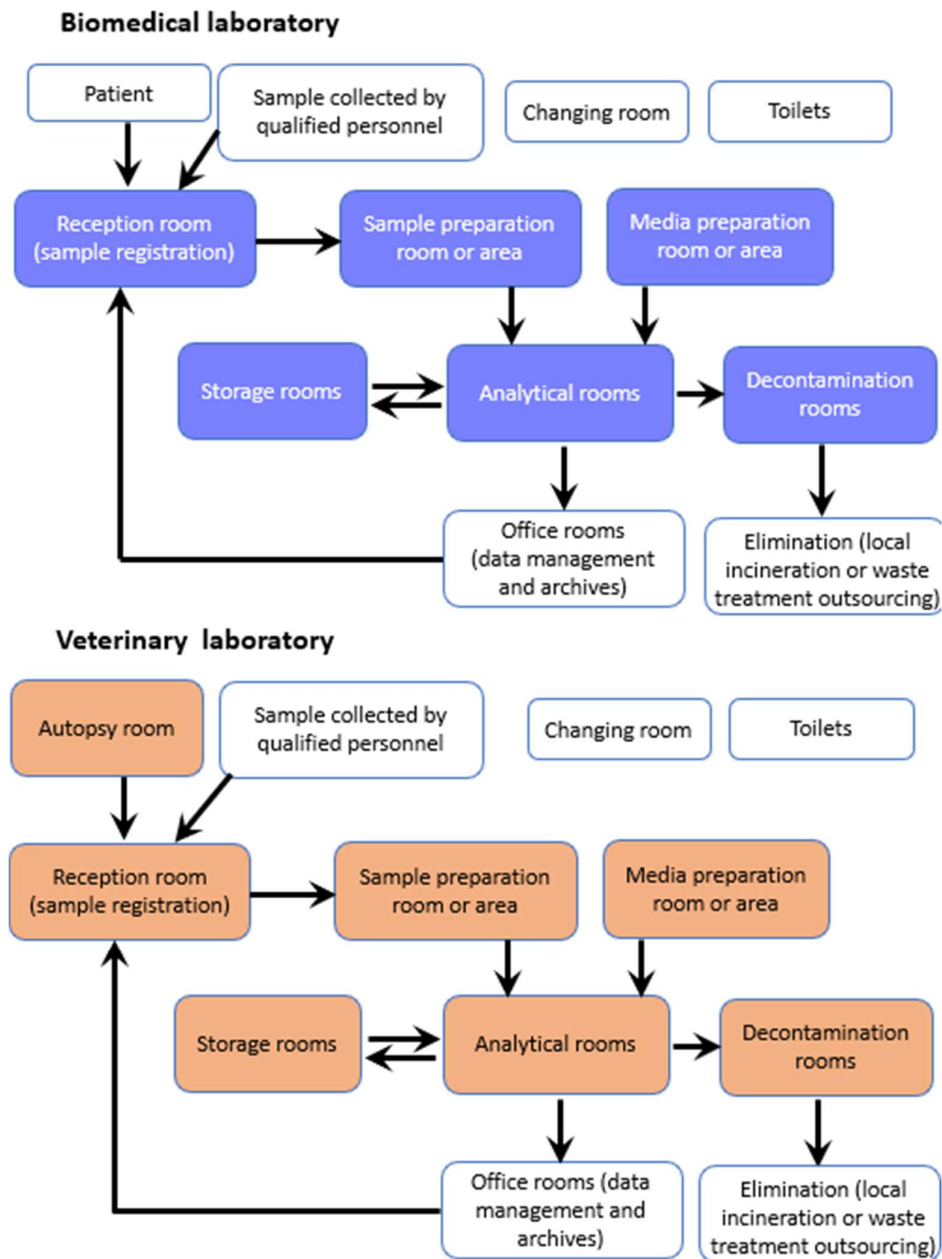
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#### **Box 1. Summary of main lessons learnt**

- The laboratory needs assessment tool was able to identify gaps in laboratory capacity and guide equipment acquisition and laboratory renovation to establish foundational microbiology services.
- The procurement catalogues are often the most comprehensive guide for reagents and consumables procurement available to stakeholders involved in bacteriology diagnostic and antimicrobial resistance surveillance in low-resource settings.
- To ensure a thorough assessment, the participation of laboratory experts, domain specialists (e.g. veterinarians or environmental microbiologists) and engineers is needed to evaluate essential infrastructure such as electrical and water systems.

Fig. 1. **Schematic layouts of rooms and areas evaluated in the laboratory needs assessment tool for biomedical laboratories and veterinary laboratories**



Note: coloured boxes indicate areas or rooms under consideration for refurbishment and equipment needs assessment.