The Mini-Lab: accessible clinical bacteriology for low-resource settings

Antimicrobial resistance represents a threat to global health-care systems. Low-resource settings especially struggle to diagnose and effectively treat bacterial pathogens.[1] In 2015, Médecins Sans Frontières (MSF) asked whether high-quality clinical bacteriology can be implemented in the most remote, challenging, and underserved areas of the world to improve treatment and surveillance of antimicrobial resistance infections. In July, 2019, MSF launched the first step to a possible answer. A field trial (unpublished) began, of the Mini-Lab; a transportable, self-contained, quality assured, stand-alone clinical bacteriology laboratory that can be operated by inexperienced technicians and used in low-resource settings.

Previously, mobile laboratory solutions have focused on outbreak investigations and used containers, truck platforms, or pelican suitcases to transport and store minimally adapted laboratory equipment and consumables. Most mobile laboratory solutions use expensive molecular technologies that demand skilled technicians and are focused on single pathogen detection.[2–4] The Mini-Lab, designed by MSF and partners, is currently in prototype form and aims to respond to constraints in low-resource settings. The Mini-Lab was created by identifying a six building-block framework for clinical bacteriology in low-resource settings, and the built-in equipment can be operated by non-expert laboratory technicians without previous microbiology experience.[5] It uses simple and affordable culture-based technology and quality-assured, standardised antibiotic susceptibility testing to improve patient care, provide surveillance data, and support the control of hospital-acquired infections.[6] The Mini-Lab is patient-directed, built-for-purpose, guided by clinical reality, and not simply an entry-level version of its counterparts for high-resource settings.[7,8]

The Mini-Lab diagnoses bloodstream infections using a manual detection system (ie, not-automated), in which blood culture provides preliminary pathogen group classification, followed by full pathogen identification (biochemical testing) and antibiotic susceptibility testing (microbroth dilution method). Antibiotic testing panels meet the MSF field criteria (unpublished), WHO Essential Medicines List,[9] and WHO recommended Global Antimicrobial Resistance Surveillance System indicators.[10] A fully functional Mini-Lab prototype was first tested in a controlled environment in Brussels on January, 2019, and is currently being tested in an MSF hospital in Port-au-Prince, Haiti.

The Mini-Lab is composed of six numbered and colour-coded bench-boxes, or workstations (figure). Each box contains equipment for its respective workstation and can be shipped as a kit or individually. Upon arrival, each box unfolds into a fully equipped and ready-to-use workbench; simplifying equipment ordering processes, overcoming procurement constraints, reducing laboratory set-up time, and organising workflow. If a

For the **Mini-Lab video** see https://fondation.msf.fr/projets/mini-lab

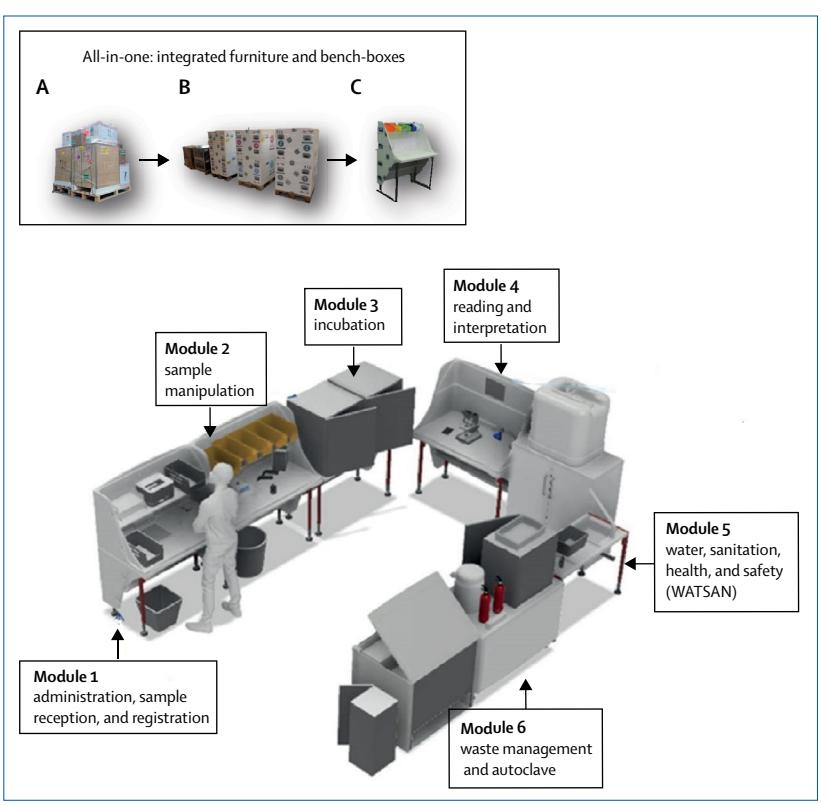

Figure 1: **Mini-Lab layout and components**
Mini-Lab set-up covers a 20 m^2 area and has six bench-boxes that can be folded and shipped together (top left corner). (A) Ready to ship the Mini-Lab. (B) Folded bench-boxes and equipment. (C) Bench-box unfolded and in working bench configuration. Each box contains all the equipment necessary for its activities. Once opened and set-up, each bench-box becomes a workstation. The Mini-Lab's portability allows its deployment in various spaces ranging from hospital rooms, to a maritime container, or a tent.

hospital meets the minimal infrastructure requirements of having an available area around 20 m², washable floors and walls, access to clean water, electricity (even if fluctuating), and waste disposal, then it can install a Mini-Lab.

An integrated quality management system using the WHO Stepwise Laboratory Improvement Process Towards Accreditation criteria[11] reduces inter-operator variability and errors, and includes; quality management manuals, equipment monitoring systems, specific standard operating procedures, and informative illustrated bench-aids designed for non-microbiology experts. Tablet-based guided data entry and workflow-assistance software were also designed for non-expert users to improve daily data entry, reduce transcription errors, increase reporting consistency, and coordinate surveillance data.

Blood culture bottles, sub-culture media, identification and antibiotic susceptibility testing microplates, and other tests; are compact, ready-to-use, and affordable. These tests were chosen because they are easy to read, interpret, and can sustain the growth of common low-resource settings and tropical bacterial pathogens. These tests have long shelf lives (12–18 months) and can be stored at 4–25°C. To reduce cost, volume, and storage space, microplates are combined to identify gram-positive and gram-negative bacteria in one plate and context-relevant antibiotics are combined into three plates.

Mini-Lab equipment is sturdy, safe, easy-to-use, requires little maintenance, and is adapted to challenging environments. The machines can withstand short power cuts and are dust safe. Waste management is integrated; an autoclave is part of the equipment included in the Mini-Lab allowing for the first step of waste processing. The autoclave is equipped with alerts for cycle and power interruptions. On-site training with theory and simulation modules (composed of a theoretical and practical session, with simulations of a typical laboratory day) provides knowledge to inexperienced laboratory technicians in a digestible way.

Although far from being complete, the Mini-Lab development process has been characterised by successes, and the lessons learned are worth sharing. Validating diagnostic tests using clinically relevant pathogens should become standard practice for in vitro diagnostics manufacturers. Engaging with private industry should be encouraged to make these products more available to low-resource settings. The validation process supports the complexity of clinical bacteriology diagnostics and calls for more innovative technologies for low-resource settings. Antimicrobial resistance impacts health and the economy worldwide; however, hospitals and communities in low-resource settings are among the most affected.[7,12] The Mini-Lab project shows that despite the challenges; engagement, inventiveness, and persistence might make it possible to bring clinical bacteriology solutions to even the most remote populations.

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