

Harnessing Mobile Diagnostics: Bringing Infectious Disease Testing to the Community

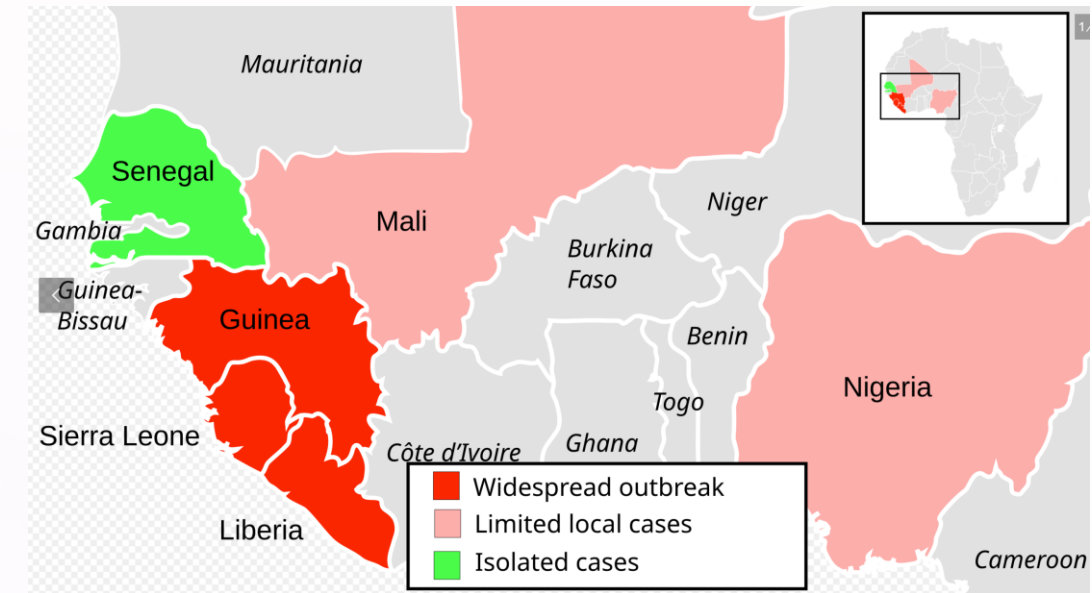
*Transforming public health through **accessible, rapid, and equitable** infectious disease testing that meets communities where they are, when they need it most.*

DR SAHLAWATI MUSTAKIM
HOSPITAL SUNGAI BULOH / 9 SEPTEMBER 2025



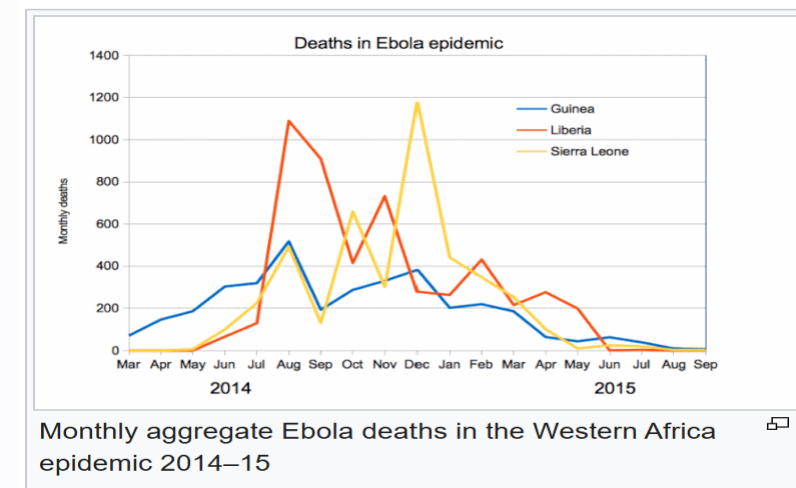
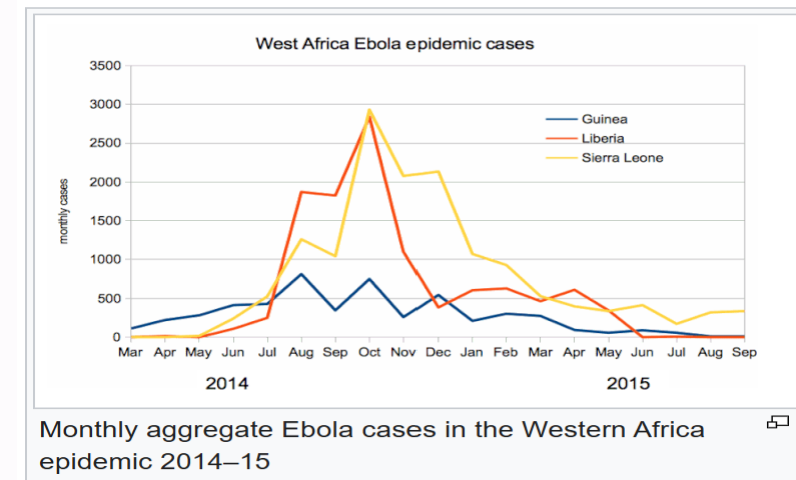
EBOLA OUTBREAK IN WEST AFRICA 2014

- The outbreak started in late 2013 but was only confirmed months later in 2014.
- It spread from Guinea to Liberia, Sierra Leone, Mali, Senegal, and Nigeria.
- After 28 months, the outbreak had resulted in **28 652 cases** and **11 325 deaths**.
- Of the dead, 518 (5%) were health-care workers.
- The combined direct economic burden and the indirect social impact was estimated to be **\$54 billion** between 2014-2016.



The slow national, regional, and global level response, including the **delays in detection of the outbreak**, forecasting, and preparation by neighbouring countries; the initial culturally insensitive community engagement and poor compliance of communities with regard to **safe burial practices**; the **misconceptions about the cause or cure of EVD**; and the limited resources coupled with **weak health systems** fuelled the initial exponential transmission in the region.³ Countries with

In 2014, during the Ebola outbreak in West Africa, patients would walk for days to a centralized lab, only to have their samples tested and wait for days more for a result. By the time it came back, they had potentially infected countless others.



The Crisis That Changed Everything

The COVID-19 pandemic exposed critical fractures in our healthcare infrastructure. Across the globe, we witnessed the devastating consequences of testing bottlenecks, delayed results, and inequitable access to diagnostics. These failures weren't merely logistical inconveniences—they cost lives.

Consider the early days of the pandemic: patients waited days for test results whilst unknowingly spreading infection. Contact tracing efforts collapsed under the weight of delayed diagnoses. Vulnerable communities—rural residents, ethnic minorities, and economically disadvantaged populations—faced insurmountable barriers to accessing testing facilities.

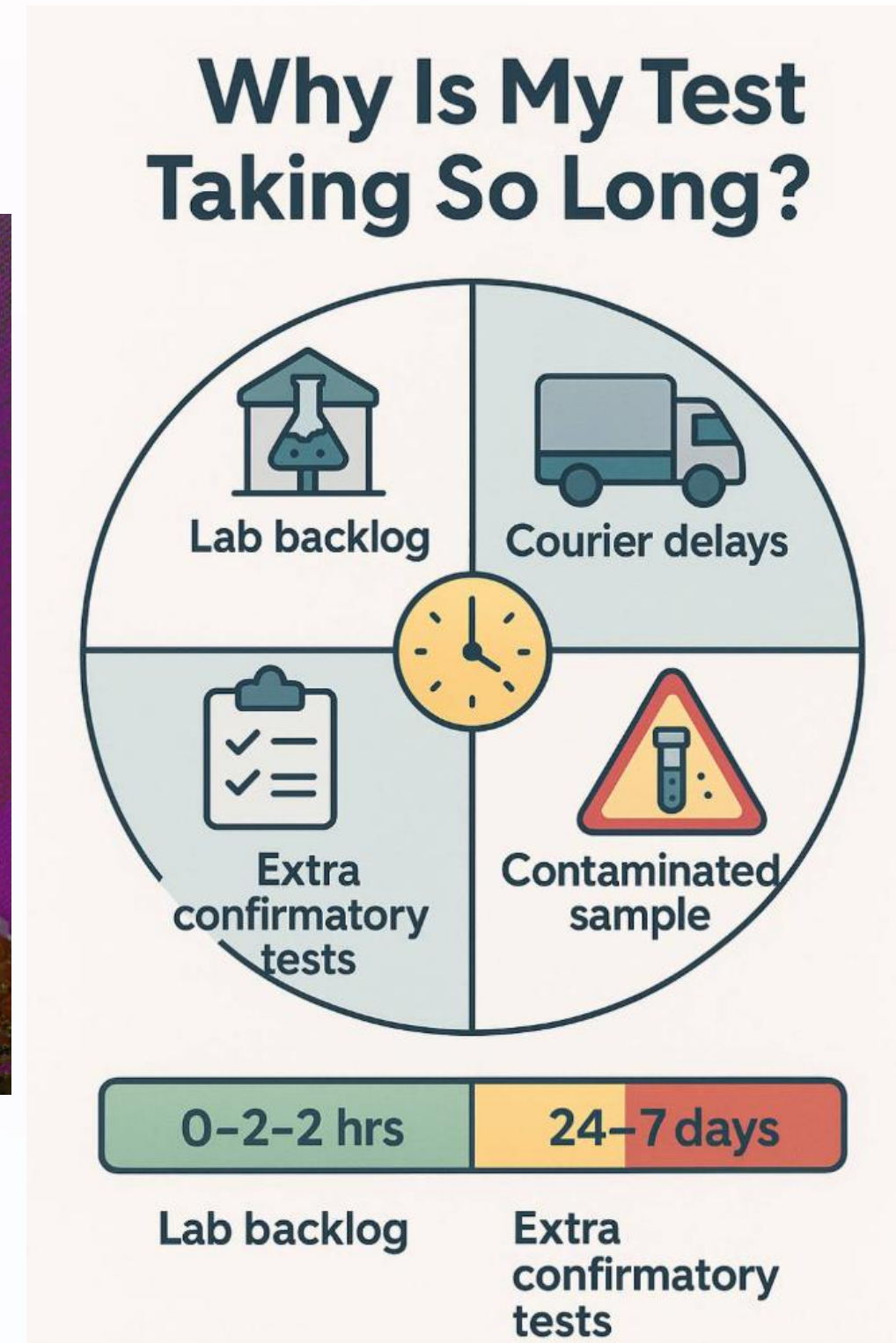
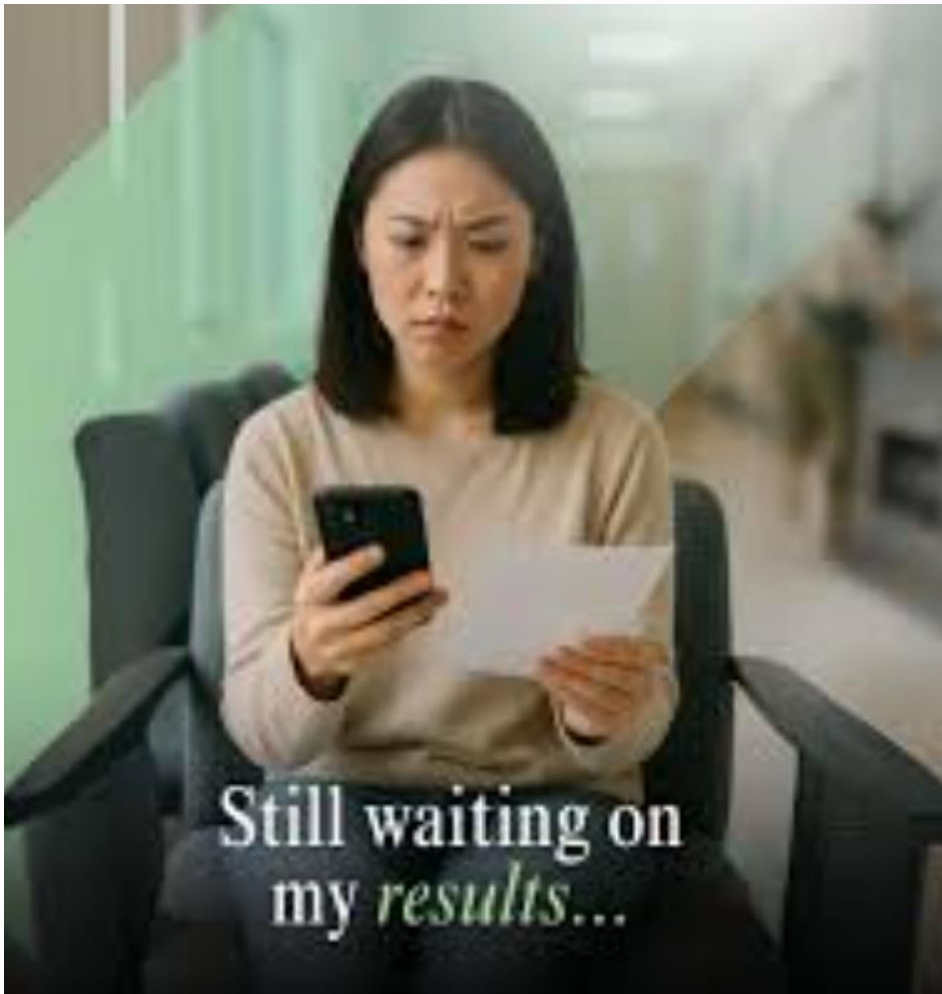
This pattern isn't unique to COVID-19. Similar challenges have plagued responses to Ebola outbreaks in West Africa, seasonal influenza surveillance, and routine infectious disease management.

The centralised laboratory model, whilst offering precision, creates dangerous delays when speed is paramount.



The Cost of Delay: Each day of delayed diagnosis increases transmission risk exponentially, particularly for highly infectious diseases.

DELAYED LAB RESULTS



Centralised Labs: The Achilles' Heel of Public Health

Centralised Labs – Acknowledge that it provides accuracy (sensitivity & specificity)

Diagnostic Bottleneck Challenges

Laboratories face capacity constraints during **SURGE** periods,

- TOO MANY samples
- Insufficient Stock/Supply for Reagen Kit/Consumable
- Limited Manpower/Skilled Personnel
- Sophisticated Analyzer/Equipment
- Cold Chain Logistics

Creating dangerous BACKLOGS

- ✓ Results reported **LATE** (Delayed TAT)
- ✓ Delayed treatment
- ✓ Lost Contact Tracing Opportunities
- ✓ Increased Transmission

Geographic Disparities

Rural and remote communities often **LACK** proximate laboratory facilities, forcing patients to travel considerable distances for testing.

This geographic barrier becomes insurmountable for many, particularly those **WITHOUT** reliable transport or the ability to take time off work.

- Rural lab access: 50+ km average
- Transport barriers for 23% of population
- Disproportionate impact on elderly

Equity Failures

Centralised testing perpetuates health inequities.

Homeless populations, undocumented immigrants, and shift workers face systemic barriers that prevent timely diagnosis and treatment, ultimately compromising community health outcomes.

- Language and cultural barriers
- Fear of healthcare system engagement

The Paradigm Shift

What if we could flip the model? Instead of the patient travelling to the lab, we bring the lab to the patient.

Mobile diagnostics make this transformation not just possible, but practical and scalable.



**We Are
HIRING**

 **RIDER FOR HOME
SAMPLE COLLECTION**

- Lab assistant /technician.
- Must have your own bike with mandatory driver's license
- Full time/Part time available



The Mobile Diagnostics Toolbox - Moving the lab to YOU

Mobile diagnostics encompasses a sophisticated spectrum of technologies, each designed to deliver laboratory-quality results outside traditional clinical settings. This isn't about compromising accuracy for convenience—it's about maintaining diagnostic excellence whilst eliminating barriers to access.



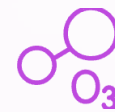
Point-of-Care Tests

Lateral flow assays and rapid diagnostic tests provide immediate results in 15-30 minutes. These user-friendly devices require minimal training and deliver reliable screening capabilities for conditions ranging from COVID-19 to malaria. Their simplicity makes them ideal for community health workers and non-laboratory settings.



Mobile Health Units

Fully equipped diagnostic laboratories on wheels. These purpose-built vehicles can be deployed rapidly to any location, complete with testing equipment, supplies, trained staff, and connectivity infrastructure for real-time data transmission to health authorities.



Portable Molecular Devices

The true game-changers: compact, battery-operated instruments using PCR or isothermal amplification. Devices like Abbott ID NOW and Cepheid GeneXpert deliver laboratory-grade molecular diagnostics in under an hour, providing the gold standard of accuracy in field conditions.



Connected Diagnostics

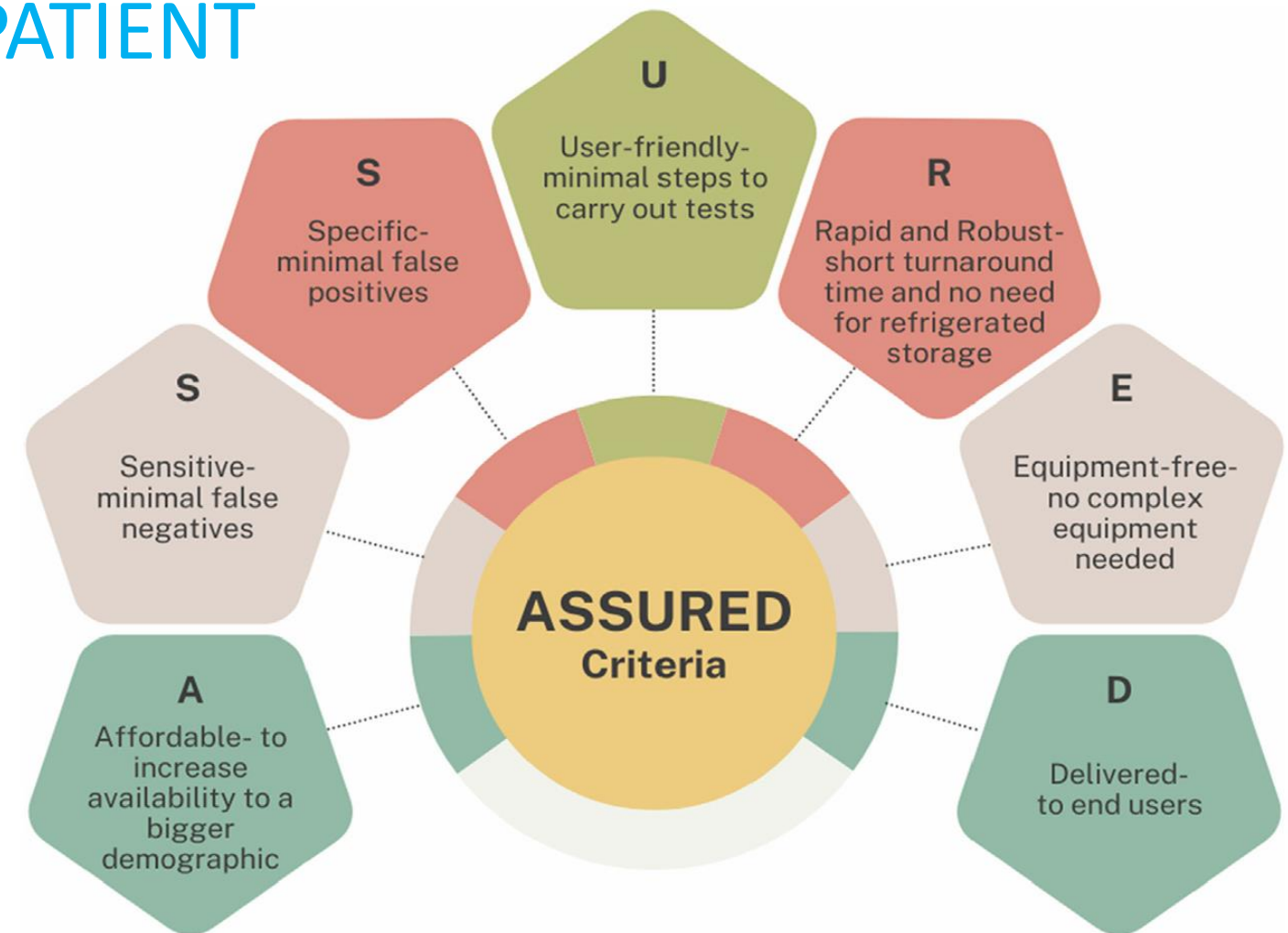
Smartphone integration transforms testing devices into connected health tools. Mobile phones serve as test readers, data transmission hubs, and platforms for patient counselling, creating seamless integration with electronic health records and surveillance systems.

The Mobile Diagnostics Toolbox - Moving the lab to YOU

Point-of-Care Tests (POCT)

RIGHT TEST – RIGHT TIME – RIGHT PATIENT

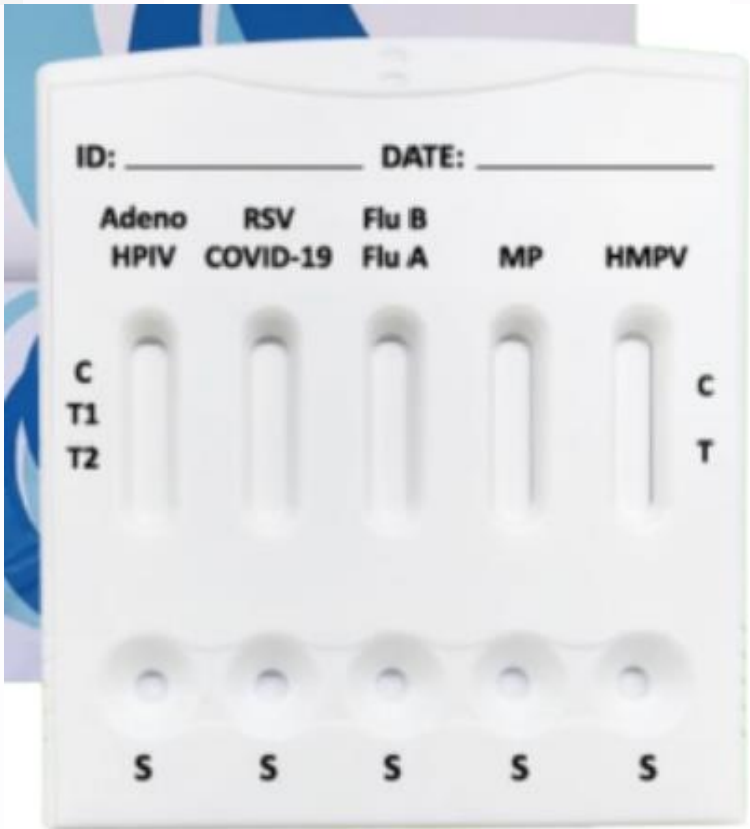
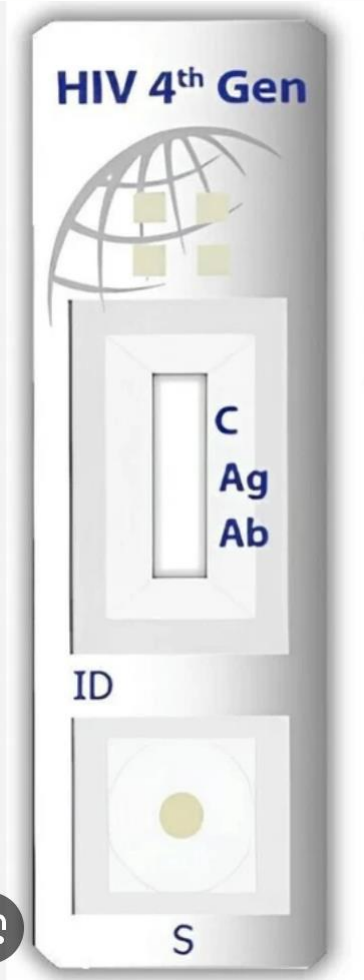
- Lateral flow assays and rapid diagnostic tests (RDTs) provide immediate results in 15-30 minutes.
- Results are visually seen
- Infectious disease : Antigen-Antibody Detection
- These user-friendly devices require minimal training – self test / home-kit test
- Rapid screening / triaging of patient
- Their simplicity makes them ideal for community health workers and non-laboratory settings.



St John, A., and Price, C. P. (2014). Existing and emerging technologies for point-of-care testing. *Clin. Biochem. Rev.* 35 (3), 155–167.

Khan AR et. Al. POCT: a critical analysis of the market and future trends. *Frontiers*. 2024

Anti-HIV 1/2



HIV Ag/Ab

The Mobile Diagnostics Toolbox - Moving the lab to YOU

Point-of-Care Tests (POCT)

Disadvantages :

- Lower sensitivity if compared with the gold standard
- Operator dependent – timing, quality of samples, reading the results
- Result usually qualitative
- Limited sample volume
- Poor integration with health records – documentation
- Data tracking issue - tracking lot numbers, expiration dates, and operator credentials for quality assurance is difficult in decentralized settings
- Risk of over-reliance on results and lack of professional guidance for home users.

Function best as a COMPLEMENT to, NOT a replacement for, centralized laboratory testing

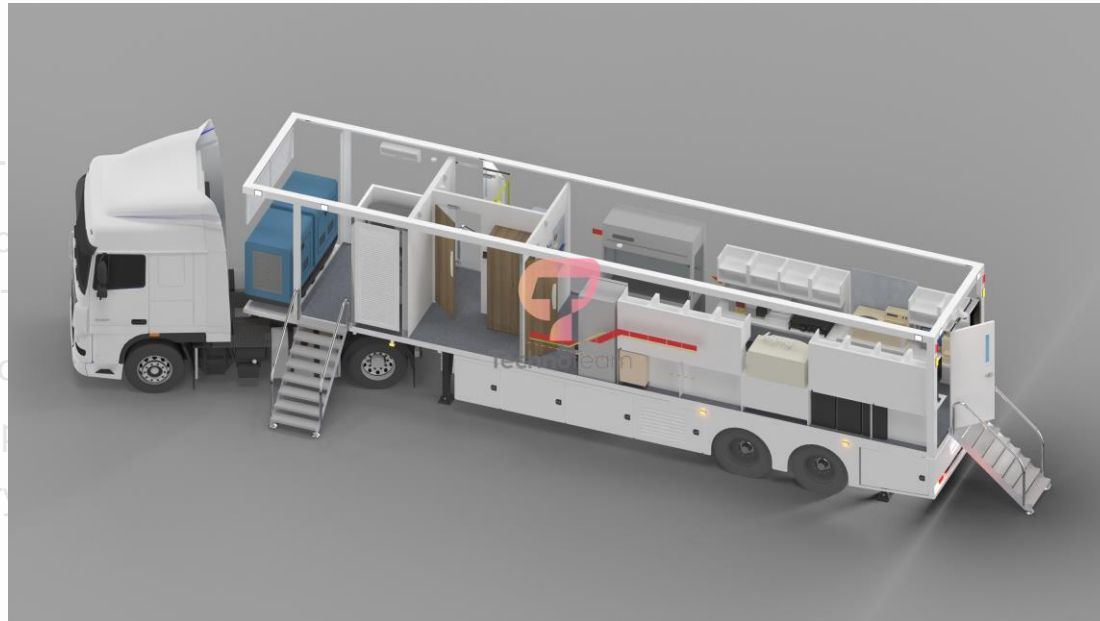
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Mobile Health/Lab Units

Fully equipped diagnostic laboratories on wheels.

These purpose-built vehicles can be deployed rapidly to any location, complete with testing equipment, supplies, trained staff, and connectivity infrastructure for real-time data transmission to health authorities.

USAGE:

1. Rural and Remote Healthcare – bringing essential medical & diagnostics services to communities
2. Disaster & Emergency Response – deploy rapidly to disaster zones (earthquake, war, floods)
3. Public Health Screening and Campaigns – vaccination drives, NCD screening, Infectious Disease testing for high-risk communities
4. Occupational Health - workers
5. Environmental Testing – lab on wheels that can test water, soil or air-quality on site
6. Advanced Diagnostic Labs – PCR analyzers and sequencing

KEY ELEMENTS:

- ✓ Strong Community Partnership – local leaders and organization
- ✓ Trained Staff
- ✓ Plan for sustainable funding

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Portable Molecular Devices

GAME-CHANGERS:

- Deliver laboratory-grade molecular diagnostics in under an hour, providing the gold standard of accuracy in field conditions.
- 1) Mini PCR - Compact, (battery-operated) instruments using PCR or isothermal amplification Deliver laboratory-grade molecular diagnostics in under an hour, providing the gold standard of accuracy in field conditions.
 - 2) Microfluidics (Lab-on-a chip) - systems that process or manipulate small amounts of fluids (10^{-9} to 10^{-18} liters) - glucometer
 - 3) Biosensors - analytical device that detects a specific biological substance (e.g., virus, glucose, toxin) and converts its presence into a measurable signal e.g. graphene-based sensors (ultra-sensitive detection) or smartphone connected electrochemical detectors
 - 4) CRISPR-Based Diagnostics - powerful genetic testing to detect specific genetic sequence or mutations of pathogens

SMART BIOSENSORS



Blood pressure monitor



Cell population biosensor



Pregnancy test biosensor



A blood- sugar monitor



A FitBit band

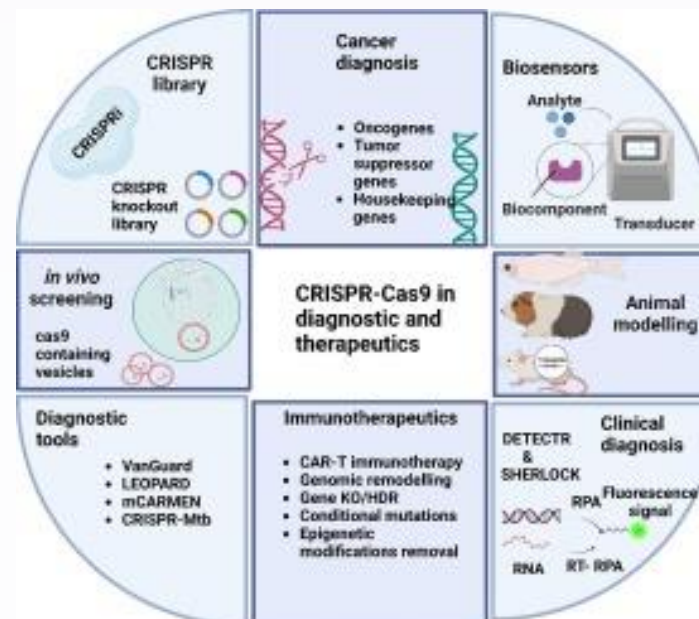


A glucometer



A digital bandage for vital signs

Saliva-based glucose biosensor



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USAGE:

1. Ubiquitous Platform – anywhere everywhere, apps with step-by-step video/instructions
2. Connectivity & telemedicine – remote monitoring and counselling
3. Geotagging – Phone's GPS can tag the location of test done & mapping disease outbreak
4. Personalized Health insights – By combining data sensors with other health information (e.g exercise, sleep pattern), the system can provide personalized feedback and recommendations (e.g “High Glucose – Consult your Doctor”)



Connected Diagnostics

- Smartphone integration transforms testing devices into connected health tools.
- Mobile phones serve as test readers, data transmission hubs, and platforms for patient counselling, creating seamless integration with electronic health records and surveillance systems

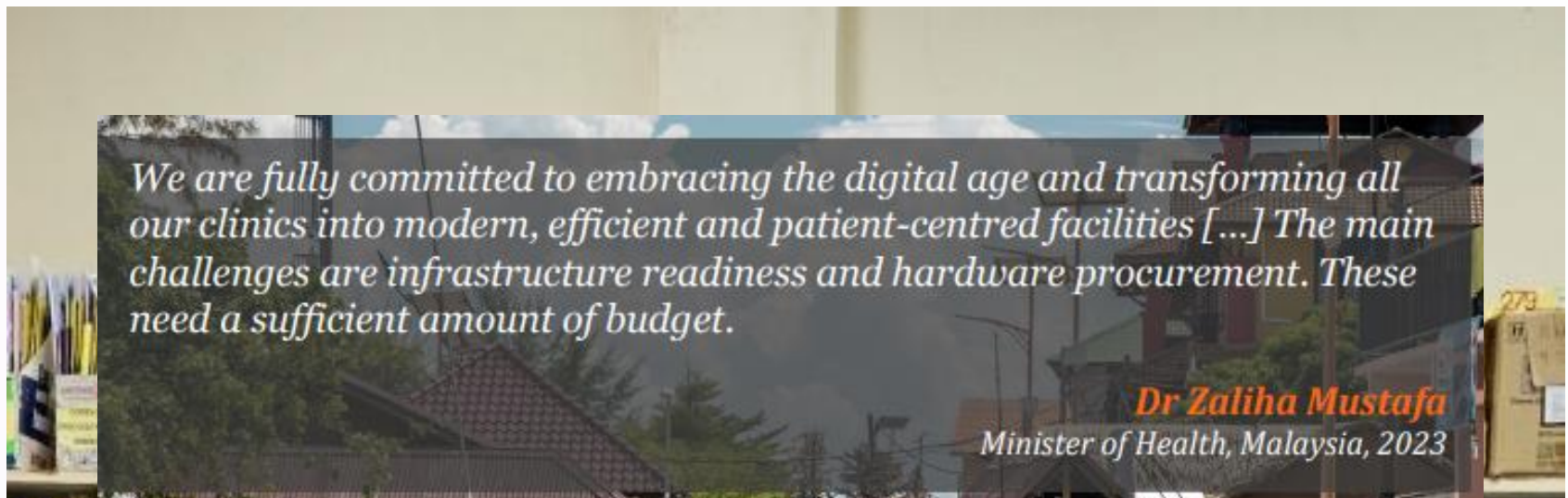
DIGITAL HEALTH RECORDS IN MALAYSIA

THE JOURNEY AND THE WAY FORWARD



Resources across the public and private sector need to be more effectively and efficiently utilised [...] Part of this work requires the sharing of patient records across facilities and providers and, towards this end, initiatives to pilot and scale up EMRs will be critical.

Khairy Jamaluddin
Minister of Health, Malaysia, 2022



We are fully committed to embracing the digital age and transforming all our clinics into modern, efficient and patient-centred facilities [...] The main challenges are infrastructure readiness and hardware procurement. These need a sufficient amount of budget.

Dr Zaliha Mustafa
Minister of Health, Malaysia, 2023



Over the next four to five years, our collective journey will lead to the establishment of an integrated Malaysian healthcare ecosystem. Through the implementation of electronic medical records (EMR) [...] we anticipate nationwide connectivity.

Dr Dzulkefly Ahmad
Minister of Health, Malaysia, 2024



**MANUAL RECORD TO
ELECTRONIC
MEDICAL/HEALTH RECORD
(EMR/EHR)**

Speed is Crucial

Speed: From Days to Minutes
90% faster clinical decision-making
Contained spread of disease



Accessibility: Meeting People Where They Are

True public health accessibility means eliminating every barrier between a person and the healthcare they need. **Mobile diagnostics** achieves this by fundamentally reimagining where and how testing occurs.

01

Community Integration

- Testing services can be deployed in familiar, trusted locations: schools, workplaces, community centres, religious institutions, and shopping centres.
- This approach removes the intimidation factor of clinical settings whilst reducing travel requirements.

03

Flexible Scheduling

- Unlike fixed clinic hours, mobile testing can accommodate shift workers, students, and caregivers.
- Evening and weekend availability ensures that economic circumstances don't prevent access to essential health services.

02

Closing the Health Gap

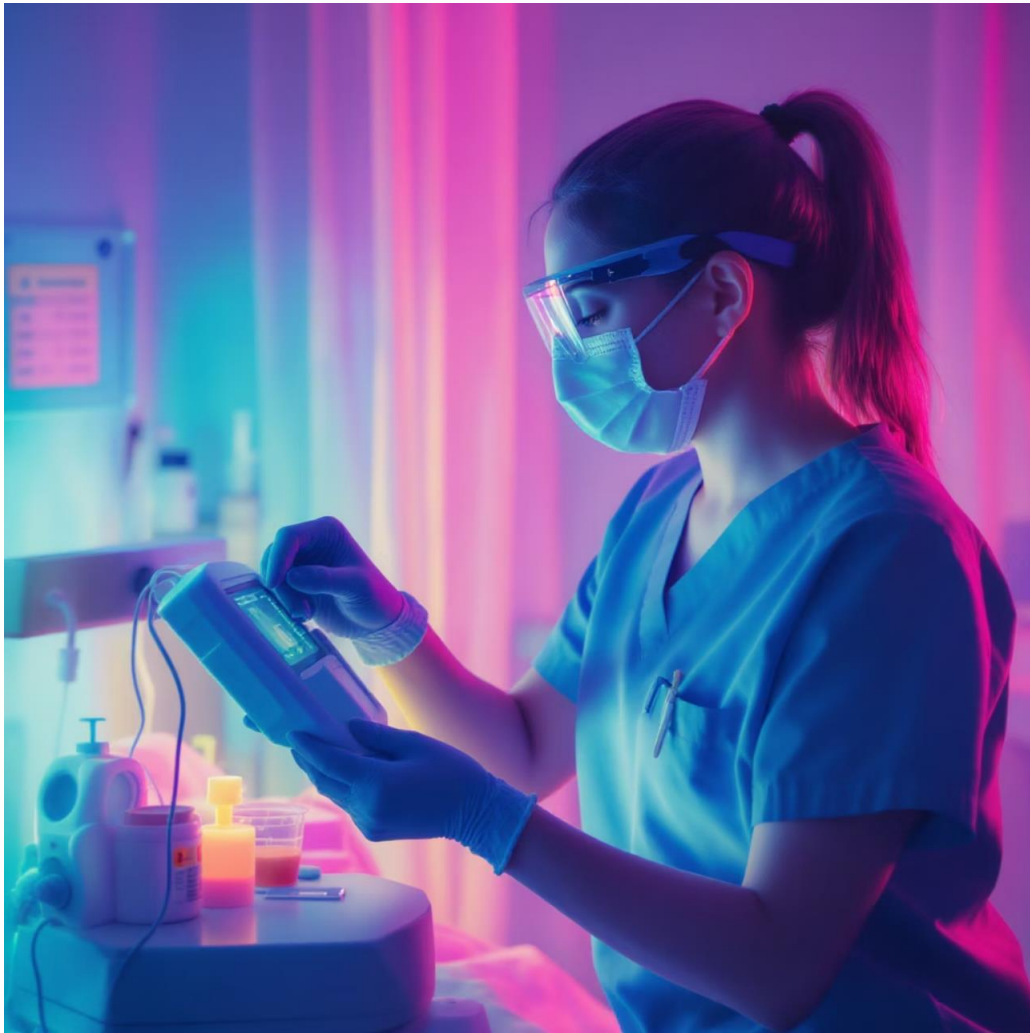
- Remove transportation barriers for rural populations
- Test done by trusted community, reduce anxiety
- Offer testing in safe spaces
- Eliminates insurance and payment barriers for screening

04

Geographic Reach

- Rural and remote communities, previously underserved by centralised healthcare infrastructure, gain access to sophisticated diagnostic capabilities.
- Mobile units can establish regular service routes, creating predictable access to testing.

Preventive Surveillance: Finding the Signal Before the Siren



- Traditional outbreak detection relies on **symptomatic** individuals seeking healthcare, creating dangerous delays.
 - By the time an outbreak is clinically apparent, substantial community transmission has likely occurred.
 - Mobile diagnostics enable **proactive "test-to-prevent"** strategies.
- ✓ Routine screening in congregate settings
 - ✓ Early detection of asymptomatic cases
 - ✓ Immediate isolation and contact tracing
 - ✓ Prevent superspreader event
 - ✓ Real-time epidemiological intelligence

Transforms
Public Health
posture from
reactive to
preventive

Navigating Implementation Challenges

Whilst the benefits of mobile diagnostics are compelling, sustainable implementation requires addressing several key challenges. Understanding these obstacles is essential for developing robust programmes that deliver lasting impact.

Regulatory Complexity

- Many diagnostic devices require MDA approval/Special Access use outside traditional laboratory settings.
- Quality assurance protocols.
- Engaging relevant regulatory authorities is essential.
- Consider credentials of healthcare professionals

Quality and Connectivity

- Maintaining staff training and competency
- Enrollment in External Quality Assurance Programmes
- Reliable connectivity for real-time data transmission – remote areas
- Data synchronization – health clinics, public and private hospitals, private labs, universities, army and teaching hospitals

Economic Sustainability

- Capital investment in mobile units & diagnostic equipment
- Ongoing costs of reagents, consumables, equipment maintenance
- Staffing and training expenses
- Public-private partnerships is crucial for long-term viability

The Future Horizon: Next-Generation Capabilities

Multiplex. Intelligent. Integrated.

The next generation of mobile diagnostic technologies promises capabilities that will further transform public health practice. These emerging innovations will make testing faster, more comprehensive, and more intelligent.

Multiplex Testing Revolution

Single-sample, **multiple-pathogen testing** panels will become standard. One nasopharyngeal swab could simultaneously test for COVID-19, influenza A/B, RSV, and other respiratory pathogens, providing comprehensive diagnostic information in a single test cycle.

1

AI-Powered Analysis

Artificial intelligence : automated image analysis of test results, reducing operator error and providing decision support. Machine learning algorithms will optimize testing protocols based on local epidemiological patterns.

3

CRISPR-Based Diagnostics

CRISPR technology will enable ultra-rapid, highly specific pathogen detection with smartphone-readable results. These systems will be simpler to operate than current molecular platforms

2

Continuous Monitoring / Surveillance

Wearable sensors and environmental monitoring systems will provide continuous surveillance for infectious disease biomarkers, enabling pre-symptomatic detection and early warning systems for community outbreaks.

4



Harnessing the power of artificial intelligence to combat infectious diseases: Progress, challenges, and future outlook

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GRAPHICAL ABSTRACT



PUBLIC SUMMARY

- Artificial intelligence technologies show significant promise in preventing and controlling infectious diseases.
- Advances made across all outbreak stages: pre-pandemic, early pandemic, pandemic, and periodic epidemics.
- Deep learning facilitates **early detection, risk assessment, policy formulation, and vaccine development.**
- Challenges arise from data quantity/quality, model complexity/interpretability, and individual privacy concerns.
- Promising directions lie in the deep integration of deep learning models with specific biological knowledge.

The Time for Action is Now

Mobile diagnostics are not merely a convenience—they are a necessity for building resilient, equitable, and responsive public health systems for the 21st century.

Policymakers & Funders

Invest in the development, deployment, and reimbursement structures that will make mobile diagnostics universally accessible. Create regulatory frameworks that encourage innovation whilst maintaining quality standards.

Healthcare Professionals

Advocate for integration of mobile diagnostics into standard practice protocols. Seek training opportunities to become proficient with these technologies and champion their adoption in community health programmes.

Researchers & Engineers

Continue pushing the boundaries of what's possible. Make devices more affordable, simpler to operate, and more comprehensively connected to health information systems.

Communities

Demand access to these life-saving technologies. Participate in mobile testing programmes and encourage others to utilise these services to protect individual and community health.

The future of public health is mobile, accessible, and equitable. Together, we can make it reality.



THANK
YOU
