Antibiogo as an innovative solution to detect antimicrobial resistance: from an operational need to a CE-marked diagnostic test available for low-income and middle-income countries

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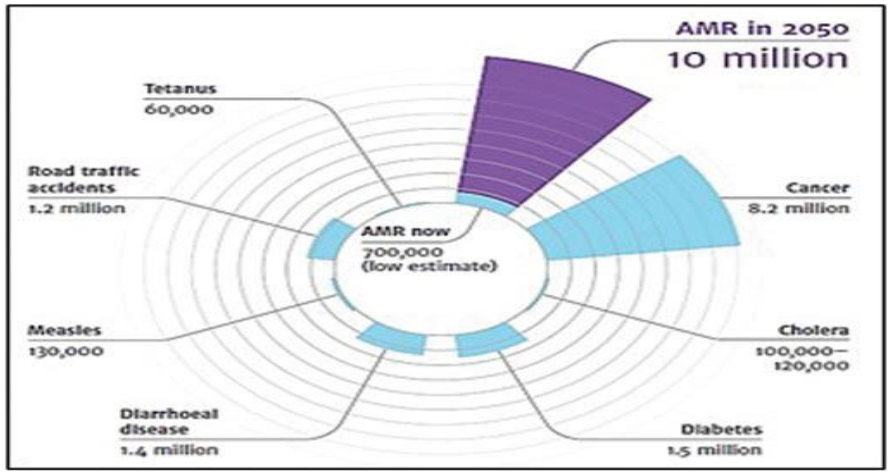
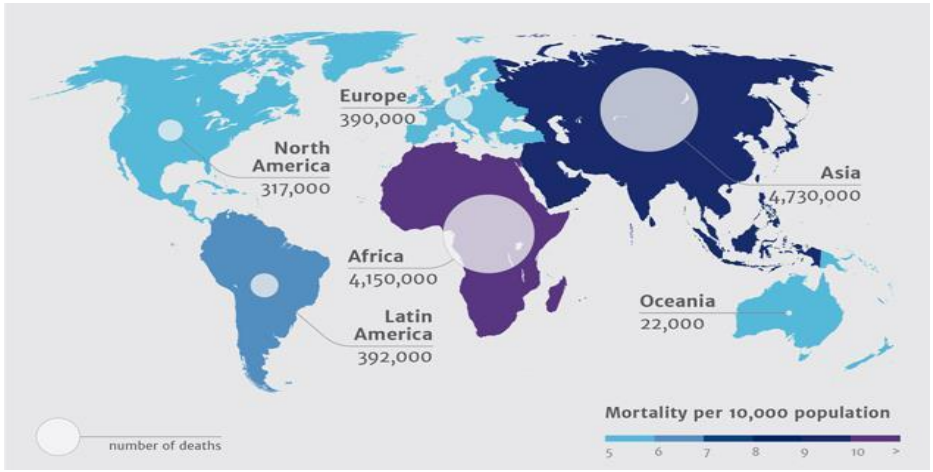
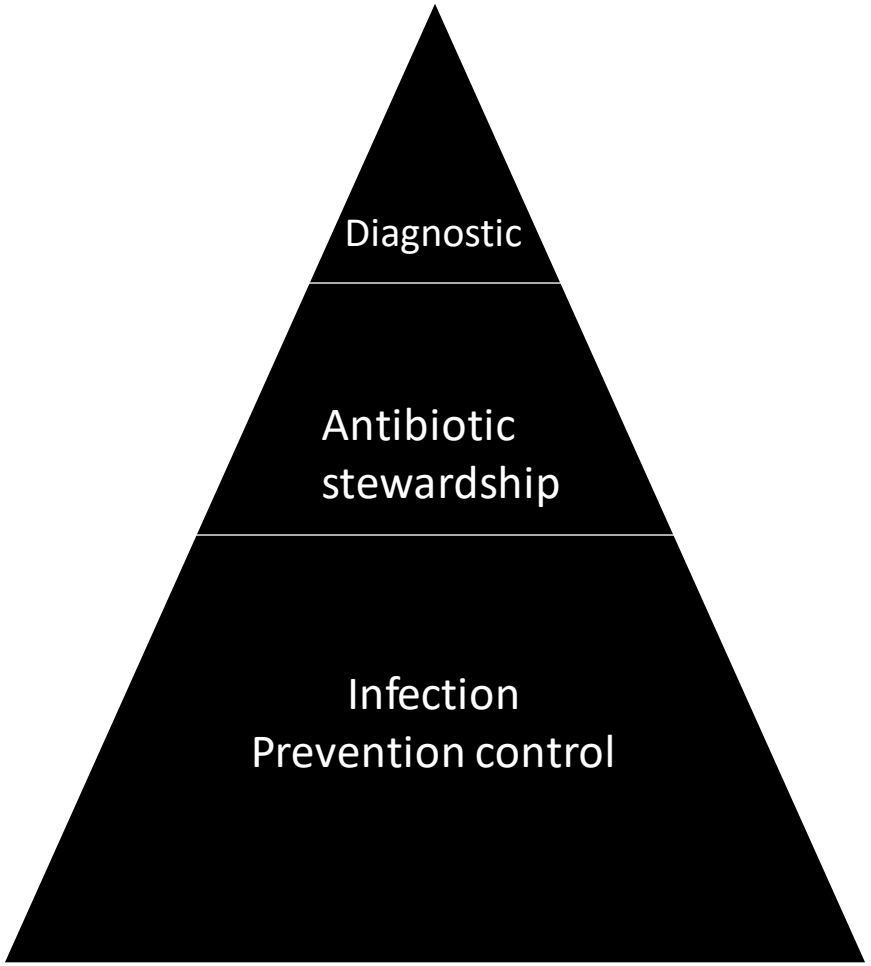
Conflict of Interest:
The author has declared no conflict of interest.

Antimicrobial Resistance: the invisible threat

- 1.29 millions deaths in 2019. (Murray et al 2022)







Acces to Bacteriological diagnostic

100% MSF labs from scratch: Yemen, Gaza, Amman, Mali, CAR, Liberia

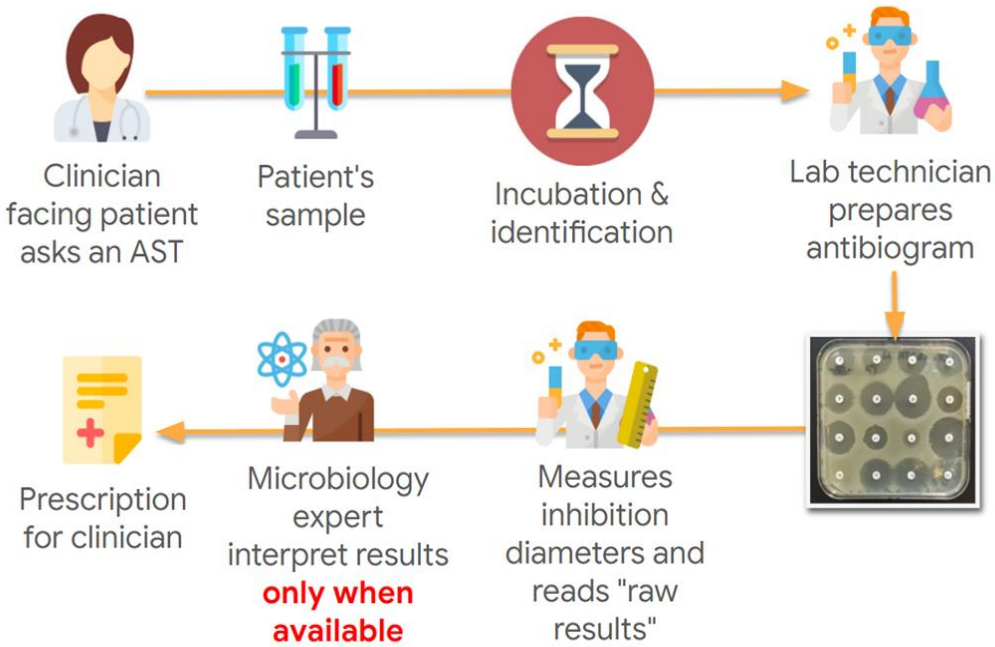
Assessment of local laboratories+ support: Iraq, North Yemen, Lebanon, Gaza, Bengladesh, Pakistan, Afghanistan…

Always same observation: Absence of interpretation

Observation confirmed in 2022: 400 years of training in sub sahara Africa

(Lancet. Fleming and al; 2021)

Diagnostic of bacterial infections and Antimicrobial Suceptibility Testing (AST)



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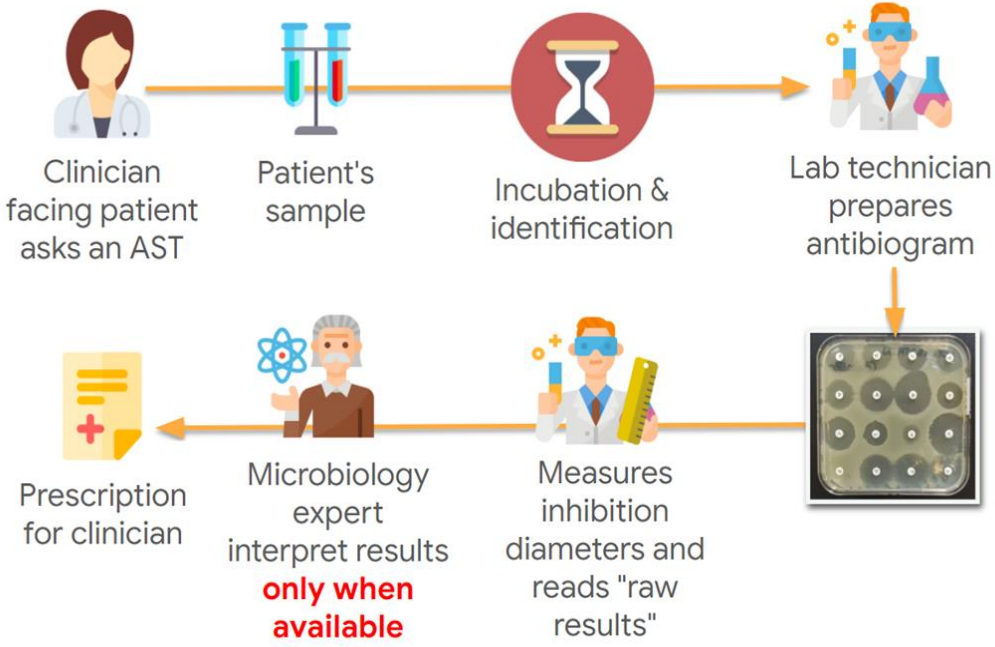
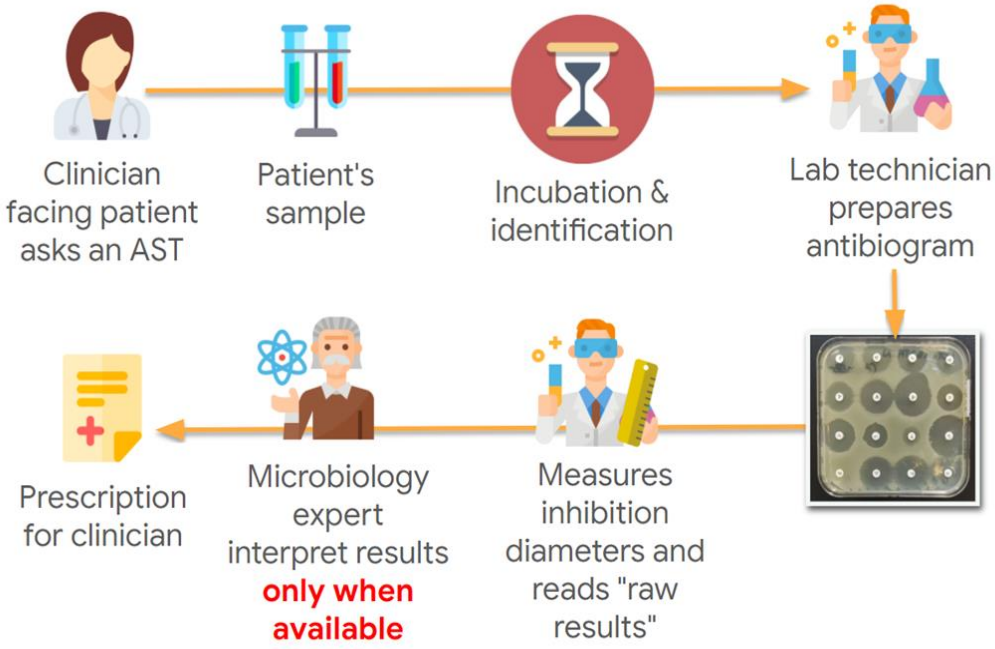


First step:
Measurement of Inhibition zone

Diagnostic of bacterial infections and Antimicrobial Suceptibility Testing (AST)



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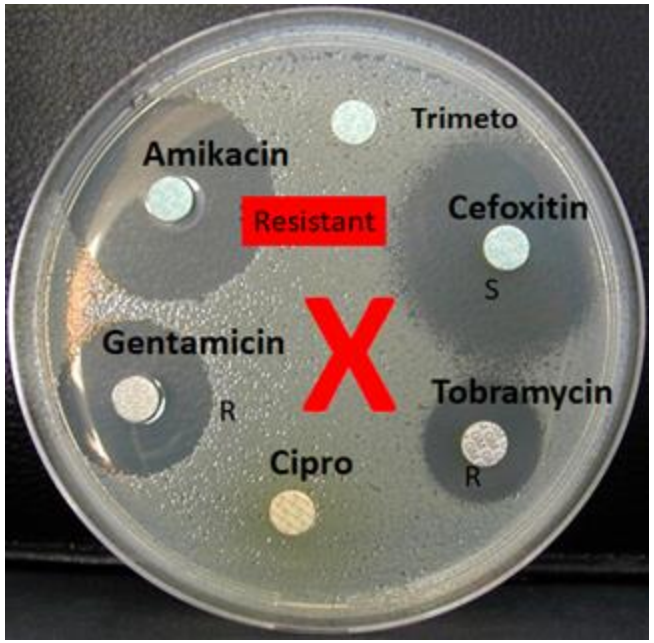

Second step:Interpretattion and application of expert rules

Antibiogo

Smartphone based application, **Free, Offline and open source**, supports laboratory technicians to **read and interpret antibiograms**

- Take picture
- Image processing+ AI: semi automatic measurement of IZD
- Expert system: Application of Breakpoint and Expert rules
- Identification of resistance mechanism
- IPC alert in case of MDR
- Results with comments to lab tech and clinicians
- Extrapolation to Antibiotics not tested
- Possibility of sending report for approval by external microbiologist

Antibiogo

Smartphone based application, **Free, Offline and open source**, supports laboratory technicians to **read and interpret antibiograms**

Antibiogo is not an App, it is a Software as medical device

- ❑ Creation of technical documentation

⬇

- ❑ Creation of quality Management System as per ISO 13485

⬇

- ❑ Clinical evaluation as per EU Directive and regulation for medical devices

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Clinical evaluation of performances as per EU In Vitro Diagnostic directives and regulation

- Evaluation in >= 3 clinical sites
- With > 300 clinical isolates: majority of fresh (7 days) + recent (<12 months) isolates, complemented if necessary with stock isolates (> 12 months)
- AST preparation & reading following EUCAST/CLSI guidelines (bacteria isolation, identification, antibiotic panels, antibiotic position on the plates, timing, etc.)
- Internal Quality Controls weekly (manual & with Antibiogo) with reference strains (ATCC) (disc diffusion & MIC)
- Antibiogo Quality Checks daily
- Repeatability & Reproducibility testing prior to enrolment of clinical isolates

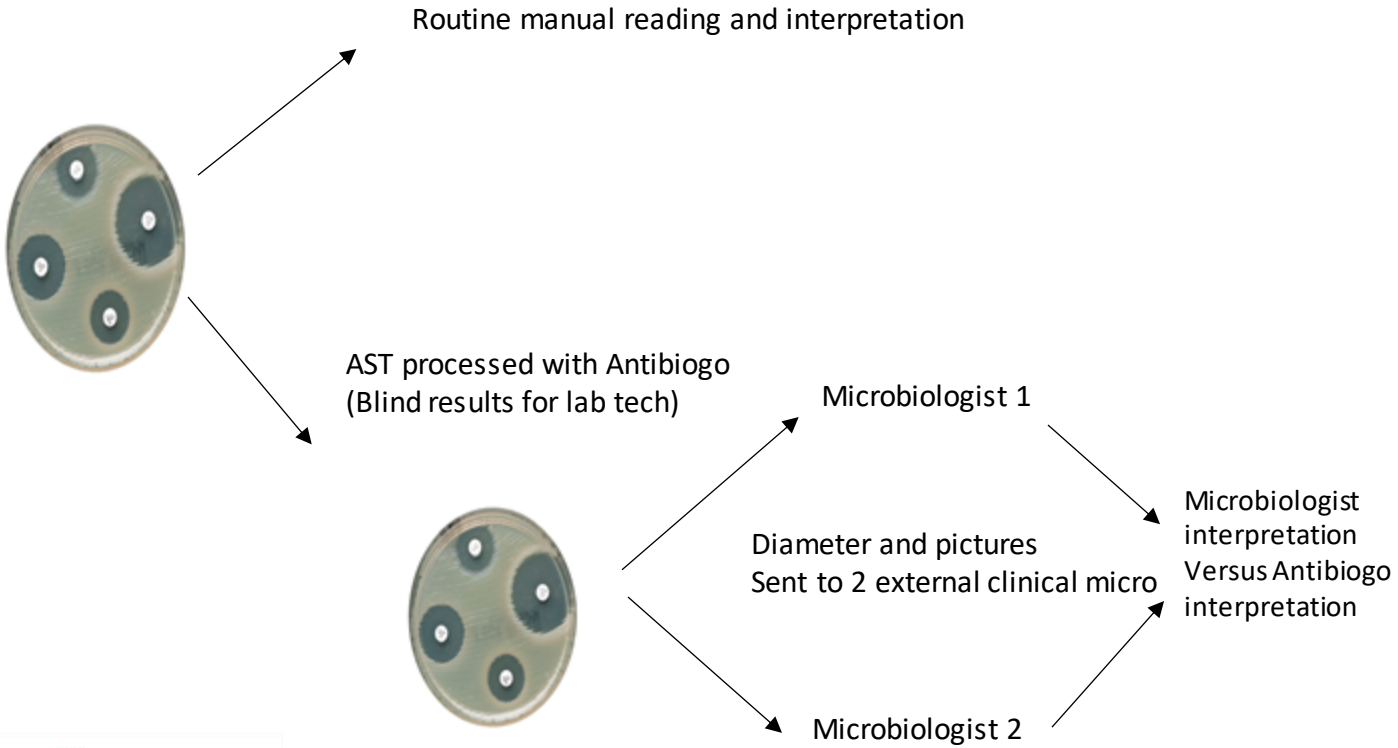
MSF pediatric project Koutiala (Mali)

MSF Reconstructive project Amman (Jordan)

Pasteur Institute ,Dakar (Senegal)

Antibiogo
Clinical evaluation as per of EU IVD

Methodology



Classification of disagreement

	Microbiologist (Gold standard)	Antibiogo
Minor diagreement	I S/R	S/R I
Major disagreement	S	R
Very major disagreement	R	S

Antibiogo
Clinical evaluation as per of EU IVDD

Tissue Isolate	# isolates per Site (%)			Total # isolates
	Jordan	Mali	Senegal	
Urine	2 (1%)	47 (32%)	100 (67%)	149
Blood culture	-	114 (100%)	-	114
CSF	-	9 (100%)	-	9
Pus	-	7 (58%)	5 (42%)	12
Ear swabs	-	-	4 (100%)	4
Vaginal swabs	-	-	23 (100%)	23
Sputum	-	-	6 (100%)	6
Tissue	46 (100%)	-	-	46
Bones	91 (100%)	-	-	91
Total	139 (31%)	177 (39%)	138 (38%)	**454**

Isolated pathogen/genera	# isolates			Total
	Site 1	Site 2	Site 3	
*Staphylococcus aureus	33	13	6	52
Coagulase negative staphylococcus (including Staphylococcus epidermidis)	32	1	3	36
Escherichia coli	6	51	52	109
Klebsiella pneumoniae	7	7	17	31
Klebsiella oxytoca	1	-	-	1
Klebsiella aerogenes	2	-	-	2
*Enterobacter cloacae	2	4	3	9
Proteus (mirabilis, species)	9	-	3	12
Citrobacter freundii	2	-	1	3
Citrobacter koseri	1	-	1	2
Serratia marcescens	5	-	-	5
Morganella morganii	-	-	3	3
Salmonella (typhii, species)	-	21	-	21
Shigella species	-	1	-	1
Providencia (rettgeri, stuartii)	-	1	1	2
*Pseudomonas aeruginosa	32	5	11	48
Pseudomonas fluroscenes	1	-	-	1
*Acinetobacter baumanii	1	4	-	5
Acinetobacter lwoffi	1	-	-	1
Pseudomonas mendocina	-	-	1	1
Enterococcus fecalis	-	10	1	11
*Enterococcus faecium	-	-	-	0
Enterococcus species	2	23	3	28
*Haemophilus (influenzae, species)	-	18	5	23
*Streptococcus pneumoniae	-	18	-	18
Others	-	-	26	29
Total Isolates	**139**	**177**	**138**	**454**

Antibiogo clinical evaluation
Overall concordance: Major and VM Disagreement

		Microbiologist interpretation			Total
		R	I (S, HE)	S	
Antibiogo Interpretation	R	1980	70	42	2092
	I (S, HE)	3	418	369	790
	S	5	74	2082	2161
Total		1988	562	2493	5043
Category Agreement			**89,8%**		
N Major Discrepancy (MD)			42		
% MD			1.6%		
N Very Major Discrepancy (VMD)			5		
% VMD			0.25%		
Weighted Kappa			0.84 (95% CI: 0.83-0.84)		

ISO recquirment: <3% VMD and MD

Concordance, (S, R, I)			
Species	# pathogen-antibiotic combinations	% agreement	Kappa (95% CI)
Staphylococcus aureus	708	96.19	0.92 (0.88 – 0.95)
Proteus mirabilis	194	87.63	0.79 (0.71-0.86)
Klebsiella pneumoniae	502	88.65	0.80 (0.76 – 0.85)
Coagulase negative Staphylococcus	351	96.58	0.93 (0.90-0.97)
Escherichia coli	1957	90.04	0.84 (0.81-0.86)
Enterococcus sp	116	93.10	0.86 (0.77-0.95)
Pseudomonas aeruginosa	607	67.05	0.50 (0.45 – 0.56)
Haemophilus influenzae	154	98.05	0.96 (0.92 – 1.00)
Streptococcus pneumoniae	106	93.40	0.88 (0.79 – 0.96)
Salmonella sp	302	91.72	0.79 (0.71 – 0.87)
Enterococcus faecalis	46	89.13	0.76 (0.57 – 0.95)

Acinetobacter baumanii, Other enterobacteria including Enterobacter, Citrobacter and Serratia under evauation in Laos and Kenya

- Majority of disagreement: minor especially with the introduction of S, IE category in 2019

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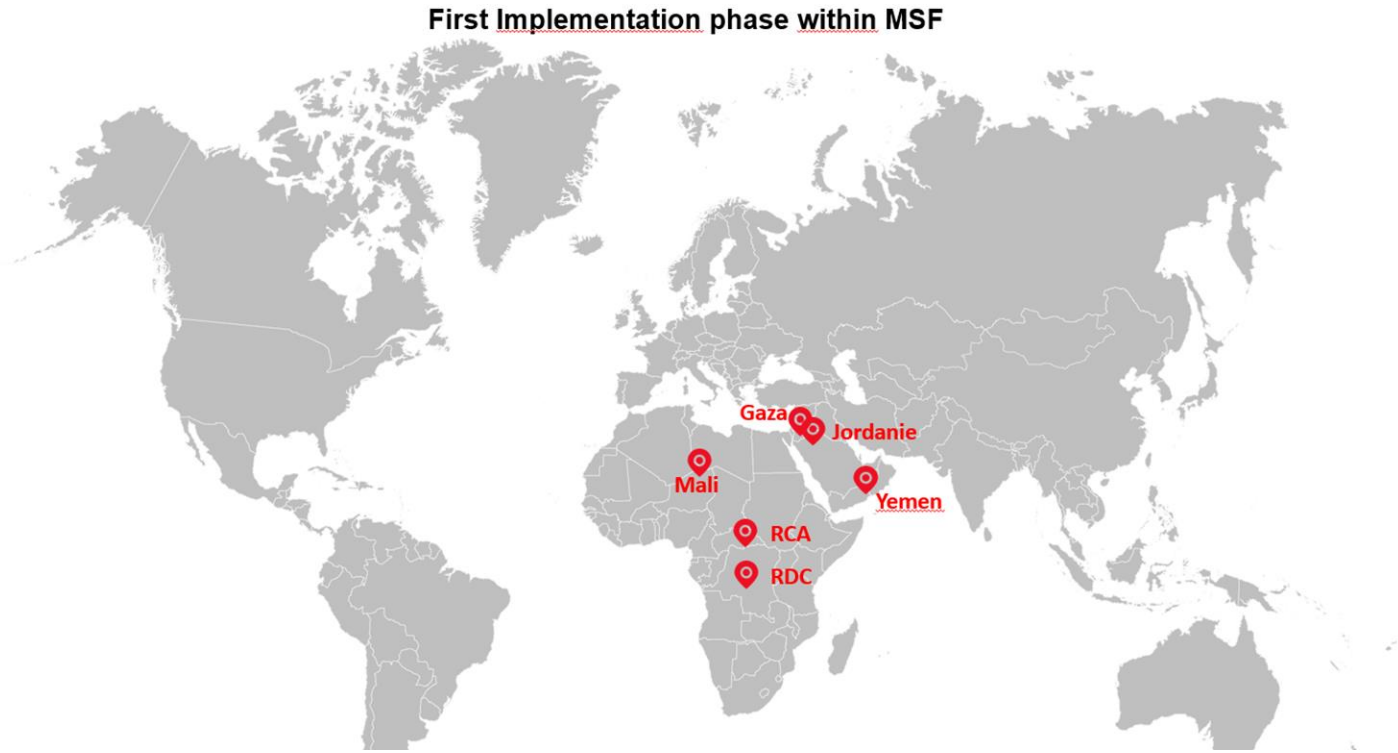
CE mark: greenlight for routine use
Sept 2022

- Implementation by an Antibiogo team member
- 5 days training: 2 hours Antibiogo/ the rest, Good AST practices: media, QC, measurments
- Exemple of Yemen: reluctance. Fear from the blax box
- Qualitative survey: post implementation + 3 months later



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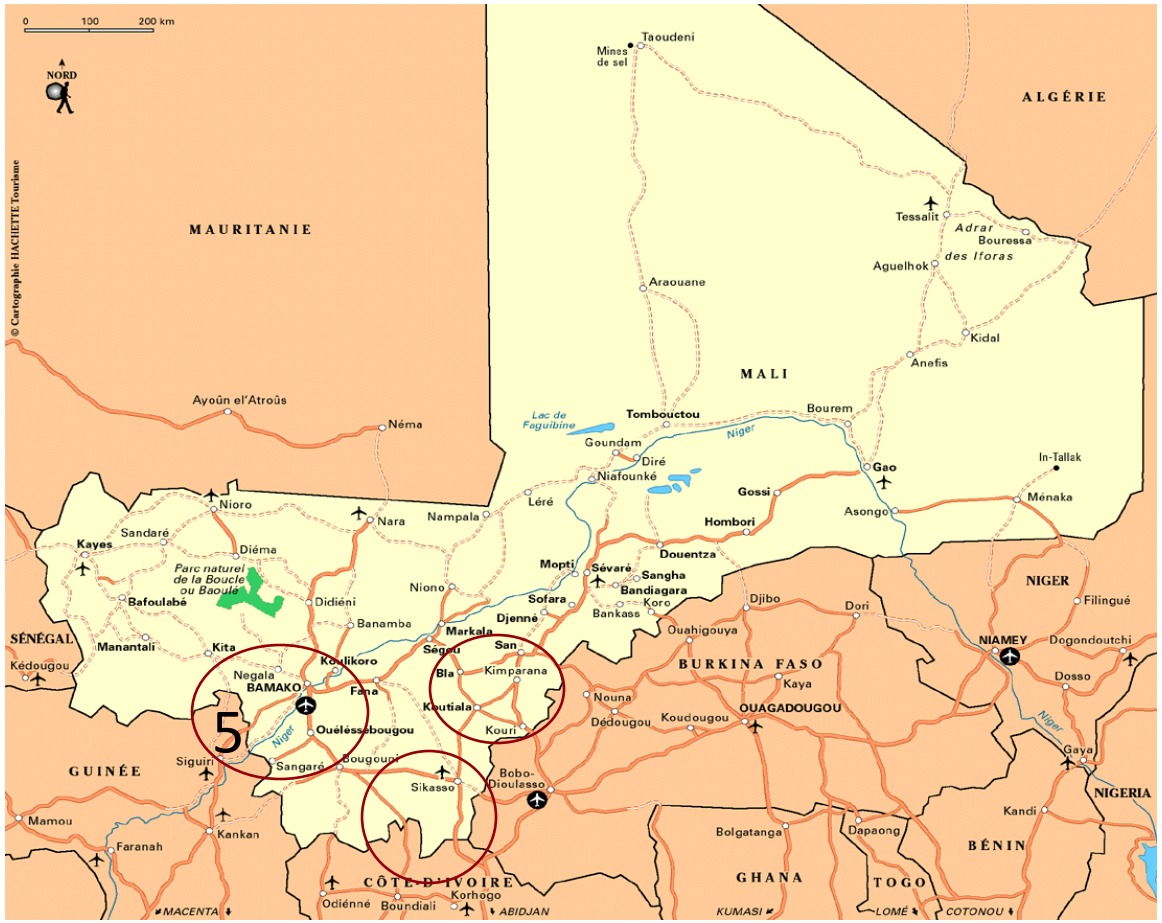
Antibiogo: first national scale up
MALI: Sept 2023

- Bamako:
  - Point G
  - Hôpital du Mali
  - Hôpital du Luxembourg
  - CICM
  - INRSP
- Hôpital de Sikasso
- Hôpital de Ségou



- 7 hospitals: between Sept-Nov 23
- Low ressources needed
- Identification of major AMR gaps at national level
- Reinforcment of OCP mission position on AMR in Mali

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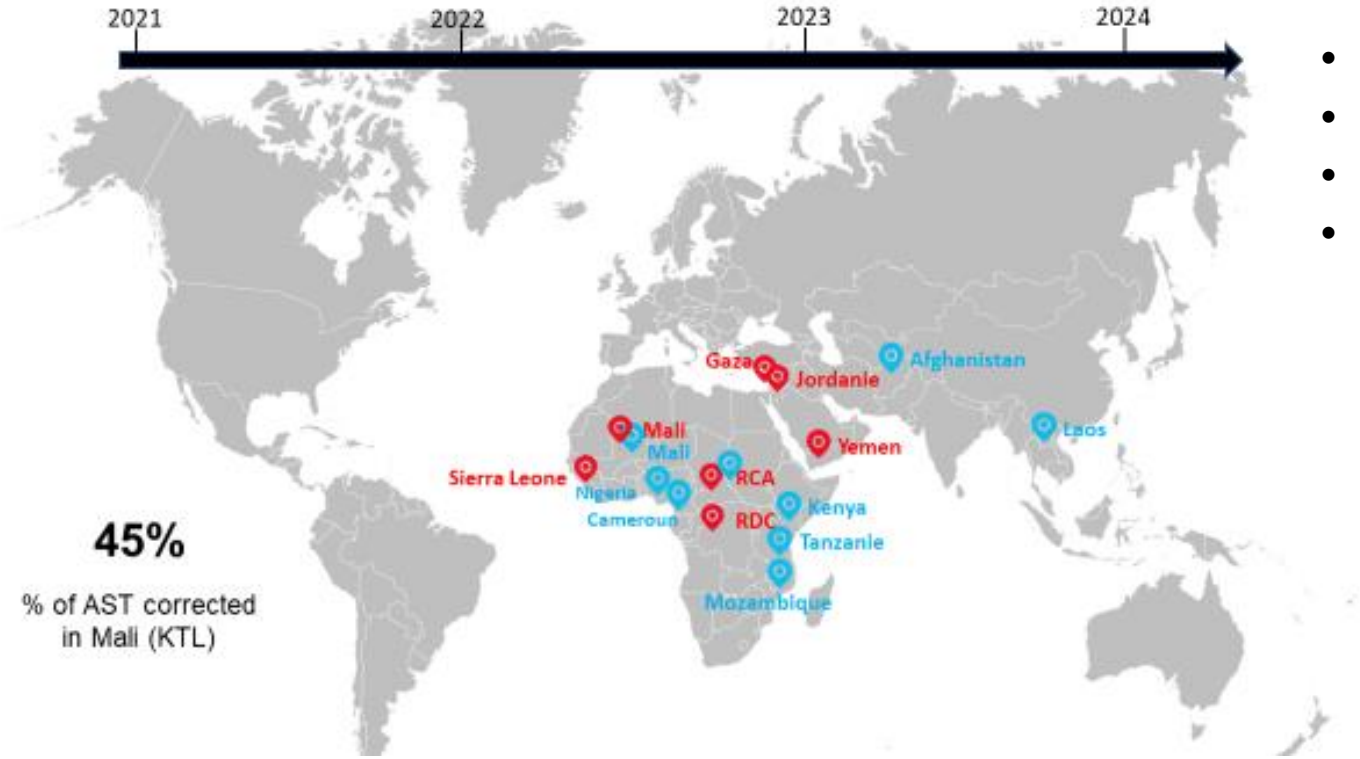
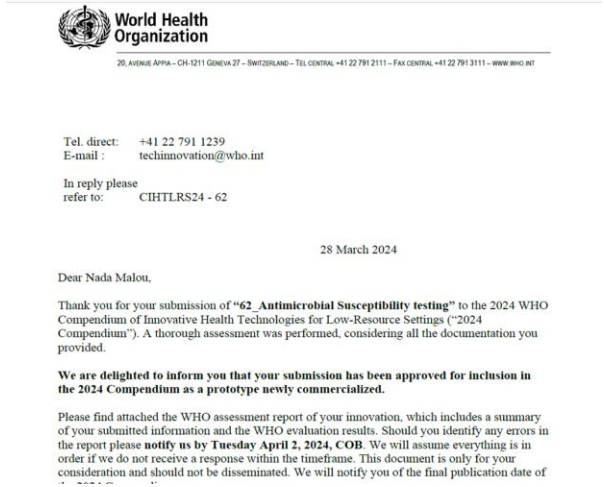
After one year of routine use in MSF hospitals, ready for scale up



- Cameroon: 7 labs
- CAR: 3 labs
- Ivory Coast: 20
- Liberia: 4



World Health Organization

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E-mail : techinnovation@who.int

In reply please refer to: CIHTLRS24 - 62

28 March 2024

Dear Nada Malou,

Thank you for your submission of **"62_Antimicrobial Susceptibility testing"** to the 2024 WHO Compendium of Innovative Health Technologies for Low-Resource Settings ("2024 Compendium"). A thorough assessment was performed, considering all the documentation you provided.

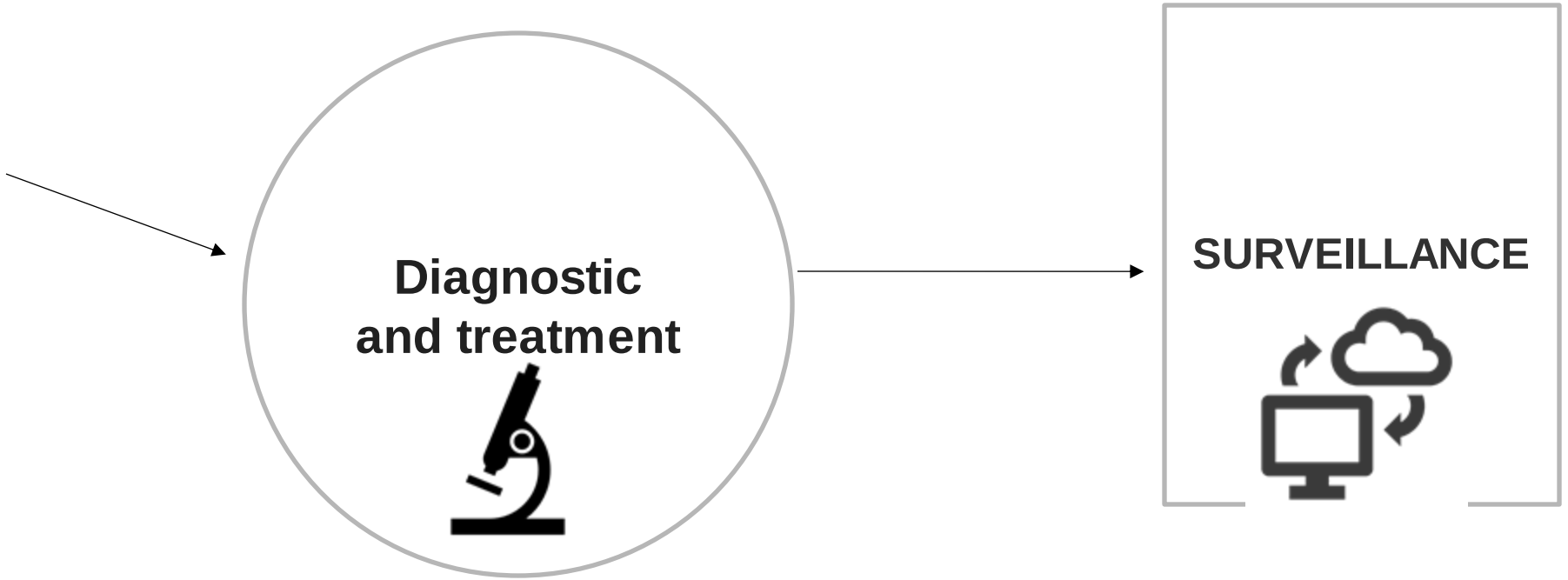
We are delighted to inform you that your submission has been approved for inclusion in the 2024 Compendium as a prototype newly commercialized.

Please find attached the WHO assessment report of your innovation, which includes a summary of your submitted information and the WHO evaluation results. Should you identify any errors in the report please **notify us by Tuesday April 2, 2024, COB**. We will assume everything is in order if we do not receive a response within the timeframe. This document is only for your consideration and should not be disseminated. We will notify you of the final publication date of

In parallel to the scale up: development of new features: surveillance and training

European Society of Clinical Microbiology and Infectious Diseases: EUCAST validation of Antibiogo

In parallel to the scale up: development of new features: surveillance and training



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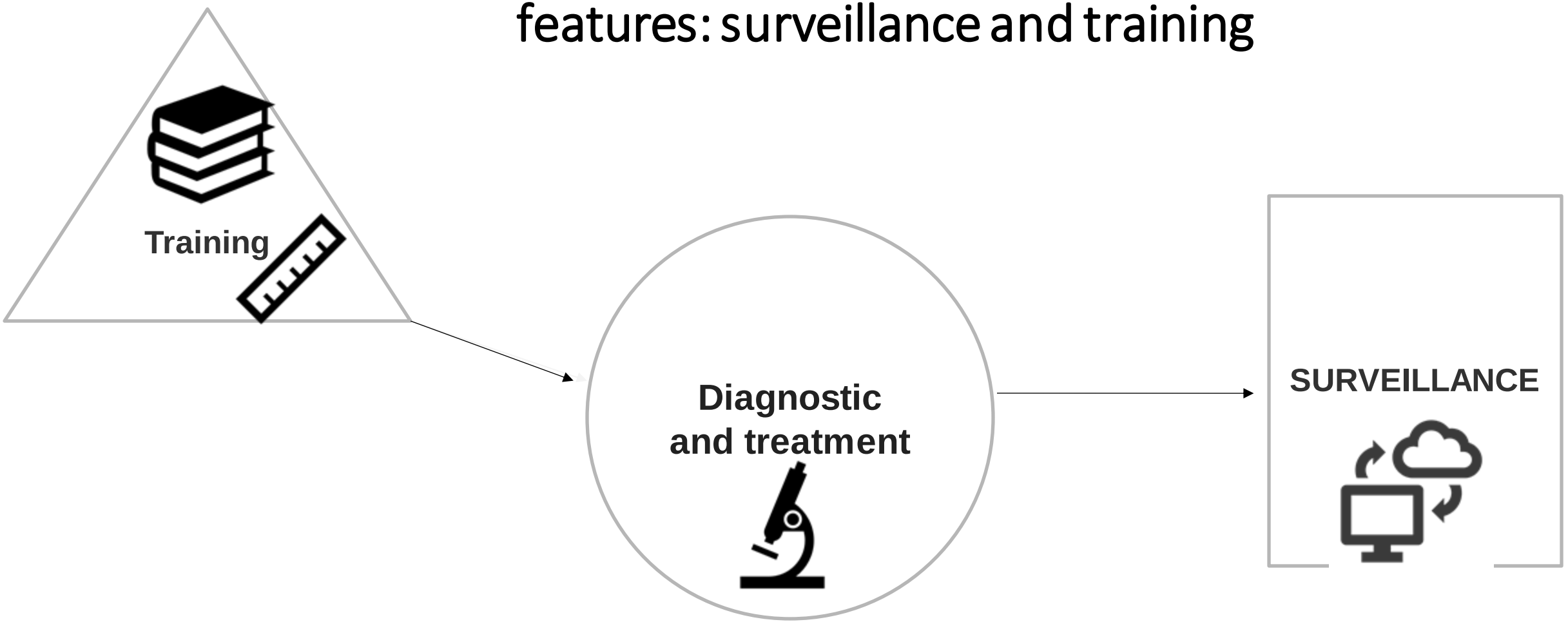
In parallel to the scale up: development of new features: surveillance and training



European Society of Clinical Microbiology and Infectious Diseases: EUCAST validation of Antibiogo

Antibiogo, In 2025

- ❑ Antibiogo available on the play store for free access by LMIC laboratories
- ❑ Self training tools available on website for a plug and play
- ❑ Not anymore a project but a medical devices used in routine for patients management
- ❑ Identification of optimal organization and set up to manage scale up and sustainable funding

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Lessons learned from Antibiogo: Digital health tools revolution: from LMIC, by LMIC for LMIC

- ❑ Health centric and Not technology centric
- ❑ Data protection and data Ownership
- ❑ Human autonomy and capacity building
- ❑ Safety, effectiveness and transparency
- ❑ Responsive and Sustainable digital tool
- ❑ Affordability

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Thank you

MSF Koutiala Project
- ❑ Fatoumata Sagara
- ❑ Adama Traore

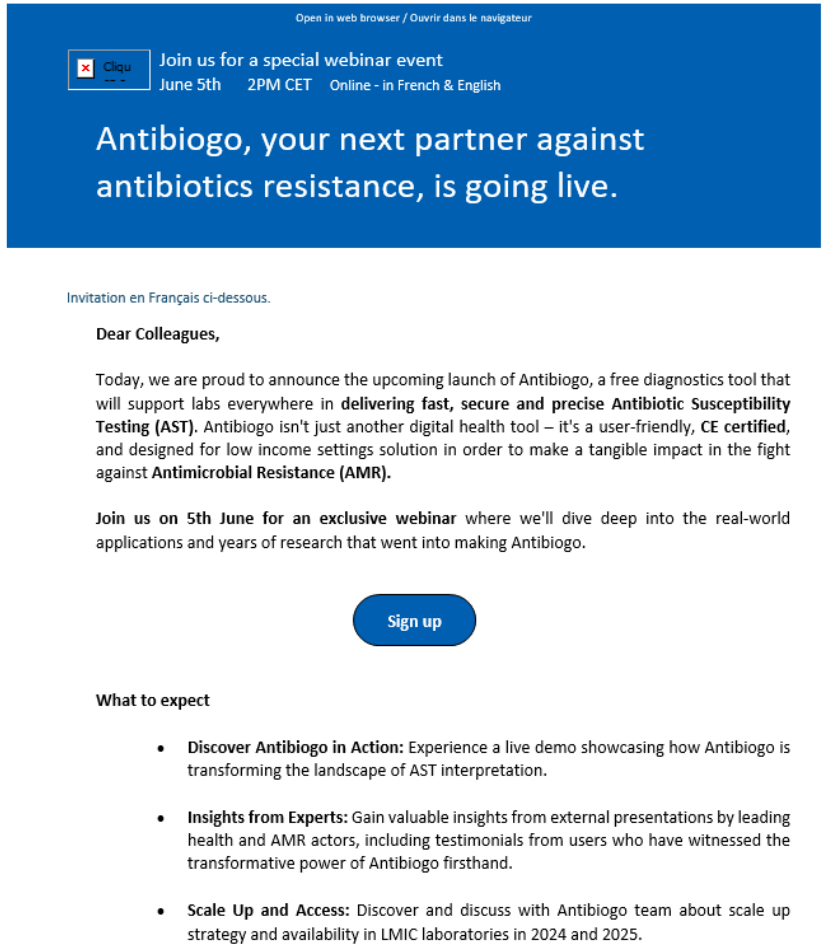
MSF RSP
- ❑ Mai al Asmar
- ❑ Dr Rasheed el Fekhri

Pasteur Institute Dakar
- ❑ Babacar Ndiaye

Antibiogo team
- ❑ Delphine Rapoud
- ❑ Vanessa Lalouelle
- ❑ Luma Kilani
- ❑ Celia Barberousse

- ❑ Andrew lover

Antibiogo webinar June 5 th : 2 to 4 pm



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Join us for a special webinar event
June 5th 2PM CET Online - in French & English

Antibiogo, your next partner against antibiotics resistance, is going live.

Invitation en Français ci-dessous.

Dear Colleagues,

Today, we are proud to announce the upcoming launch of Antibiogo, a free diagnostics tool that will support labs everywhere in **delivering fast, secure and precise Antibiotic Susceptibility Testing (AST)**. Antibiogo isn't just another digital health tool – it's a user-friendly, **CE certified,** and designed for low income settings solution in order to make a tangible impact in the fight against **Antimicrobial Resistance (AMR).**

Join us on 5th June for an exclusive webinar where we'll dive deep into the real-world applications and years of research that went into making Antibiogo.

Sign up

What to expect

- **Discover Antibiogo in Action:** Experience a live demo showcasing how Antibiogo is transforming the landscape of AST interpretation.
- **Insights from Experts:** Gain valuable insights from external presentations by leading health and AMR actors, including testimonials from users who have witnessed the transformative power of Antibiogo firsthand.
- **Scale Up and Access:** Discover and discuss with Antibiogo team about scale up strategy and availability in LMIC laboratories in 2024 and 2025.