THE GLOBAL HEALTH NETWORK
Enabling research by sharing knowledge

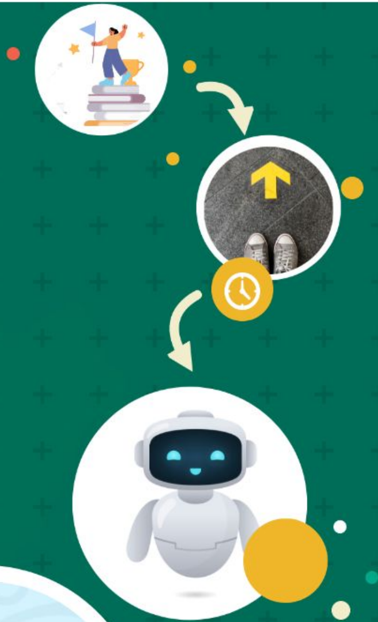
AMR Antimicrobial Resistance Knowledge Hub

THE GLOBAL HEALTH NETWORK AFRICA

FOR LEARNING AND CULTURE

World Antimicrobial Awareness Week (WAAW) 2025 Webinar Series

Act Now: Protect Our Present, Secure Our Future. Spotlight on Nigeria



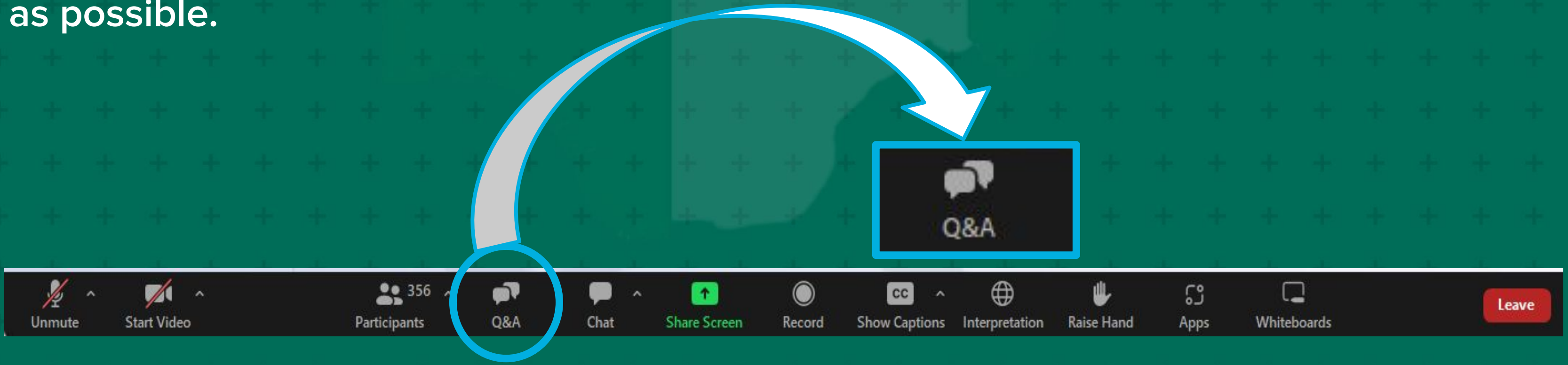
When: **20th November 2025**

Time: **09:00 GMT**

WORLD AMR AWARENESS WEEK
18-24 NOVEMBER

Housekeeping

- This webinar is being recorded and will be shared on The Global Health Network.
- Due to the number of participants your camera and microphone are disabled.
- Please use the *Chat* feature for any technical issues.
- Please use the ***Q&A*** feature to post your questions. You can post anonymously.
- We have dedicated time allocated for Q&A so we'll try to get through as many questions as possible.



Registered for today's webinar - Thank you!

Country	Attendees
Nigeria	96
Kenya	9
United Kingdom	7
Tanzania	6
Uganda	6
Malawi	5
DRC	4
Ethiopia	4
Ghana	4
India	4
South Africa	4
Benin	3
Malaysia	3
Zimbabwe	3
Bangladesh	2
Botswana	2
Germany	2
Lesotho	2
Liberia	2
Mauritania	2

Panel & Agenda

Chair: Godwin Pius Ohemu - Hub and Media Coordinator, The Global Health Network, Nigeria

Welcome/Opening Remark: Dr. Ola Ibigbami - Country Center Coordinator, The Global Health Network, Nigeria

Global Lessons for Nigeria: What We Can Learn from AMR Success Stories. - **Prof. Kome Otokunefor**, Molecular and Pathogenic Microbiologist, University of Port Harcourt

AMR in Nigeria: Current Realities, Challenges, and the Way Forward - **Dr. Chizaram Onyeaghala**, Infectious Diseases Physician, University of Port Harcourt Teaching Hospital, Port Harcourt

Harnessing Artificial Intelligence for AMR Surveillance in Nigeria - **Ugonna C. Morikwe**, Ph.D. Candidate, Applied Science and Technology, North Carolina Agricultural and Technical State University, USA.

Q&A - Prof. Kome Otokunefor, Dr. Chizaram Onyeaghala and Ugonna C. Morikwe

Closing Remark - **Goodness Ogeyi Odey** - Partnership & Advocacy Coordinator, The Global Health Network, Nigeria

Scribe - **Chinenye Chukwu-Mba**, AfOx Ubuntu Fellow

Global Lessons for Nigeria: What We Can Learn from AMR Success Stories.

Prof. Kome Otokunefor

Molecular and Pathogenic Microbiologist, University of Port Harcourt

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Molecular and Pathogenic Microbiologist,
University of Port Harcourt

Global Lessons for Nigeria: What We Can Learn from AMR Success Stories

Otokunefor, Kome PhD
Professor of Molecular and Medical Microbiology
University of Port Harcourt

Outline

- Antimicrobial Resistance (AMR)
- Antimicrobial Agents
- One Health Approach
- Key Intervention Strategies
- AMR Success Stories
- Global Antimicrobial Resistance and Use Surveillance System
- Nigeria: Current Situation
- Nigeria: Take Home Lesson

Antimicrobial Resistance (AMR)

- Ability of bugs to withstand the action of antimicrobial agents
- Renders antibiotics ineffective
- Often develop rapidly following the introduction of the drug

Antimicrobial Resistance (AMR)

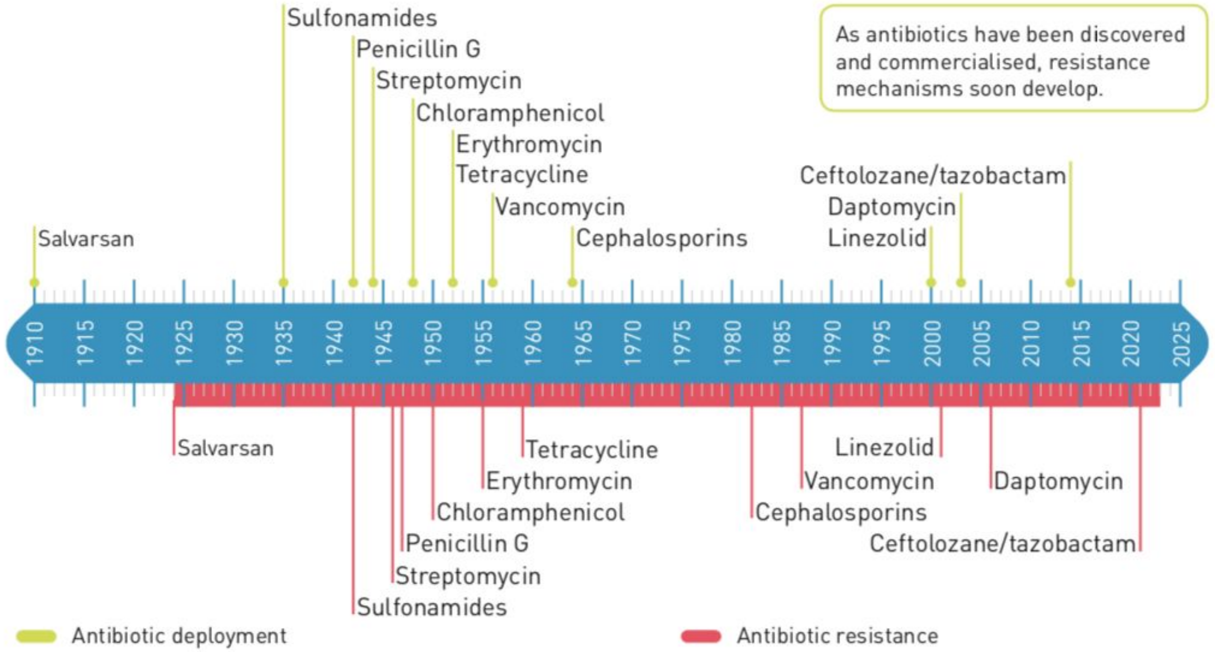


Figure 1

Commercial deployment of antibiotics and emergence of antibiotic resistance – a timeline

Antimicrobial Agents

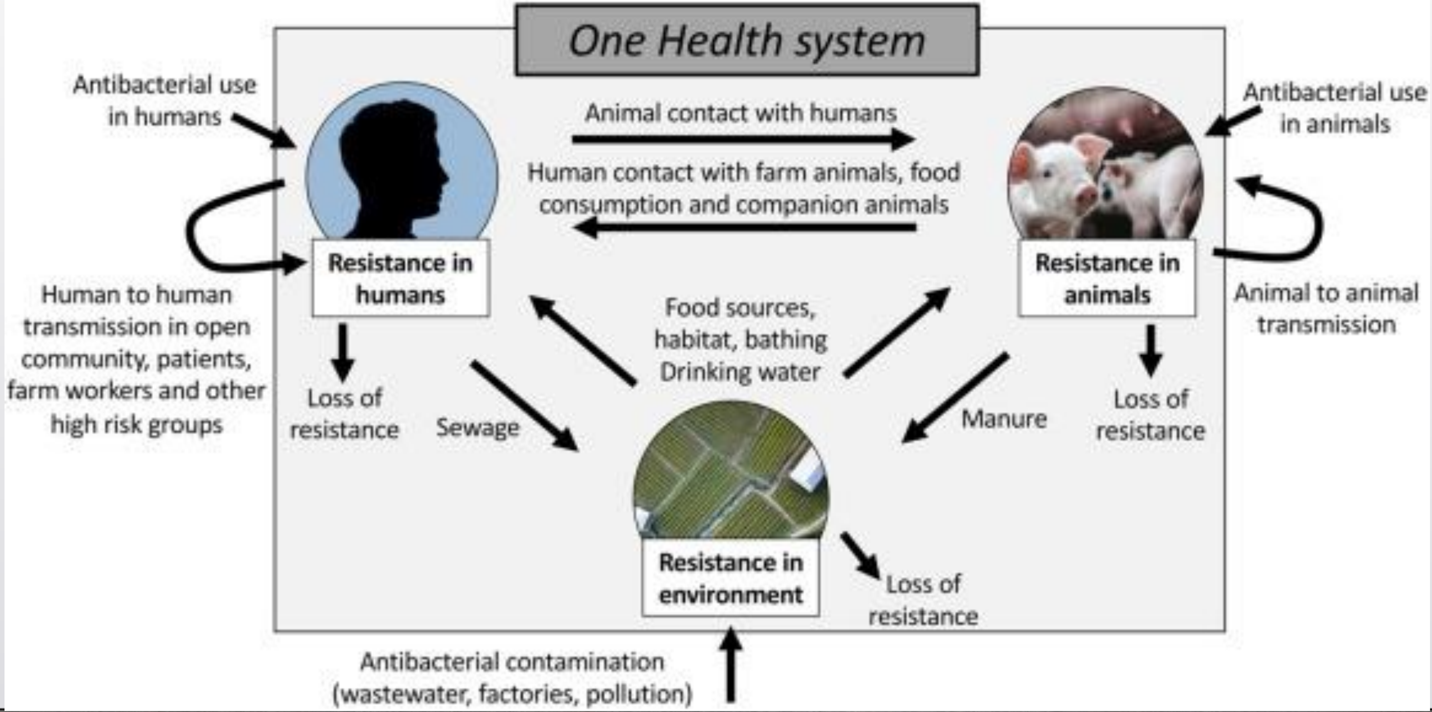
Human

- Treatment
- Prophylaxis
- Control

Animal

- Treatment
- Prophylaxis
- Control
- Growth Promoters

One Health Approach



Key Intervention Strategies


WHO Global Action Plan
One Health Approach
Surveillanc e Systems
AMS Programs
IPC Measures
R&D & Innovation
Policy and Regulation
International Collaboration
Interventio n Type

WHO Global Action Plan

Objectives

- Improve awareness and understanding of antimicrobial resistance
- Strengthen knowledge through surveillance and research
- Reduce the incidence of infection
- Optimize the use of antimicrobial agents
- Ensure sustainable investment in countering antimicrobial resistance

FAO Action Plan on AMR

- Increasing stakeholder awareness and engagement
- Strengthening surveillance and research
- Enabling good practices
- Promoting responsible use of antimicrobials
- Strengthening governance and allocating resources sustainably

WOAH Strategy on AMR

- Improve awareness and understanding
- Strengthen knowledge through surveillance and research
- Support good governance and capacity building
- Encourage implementation of international standards

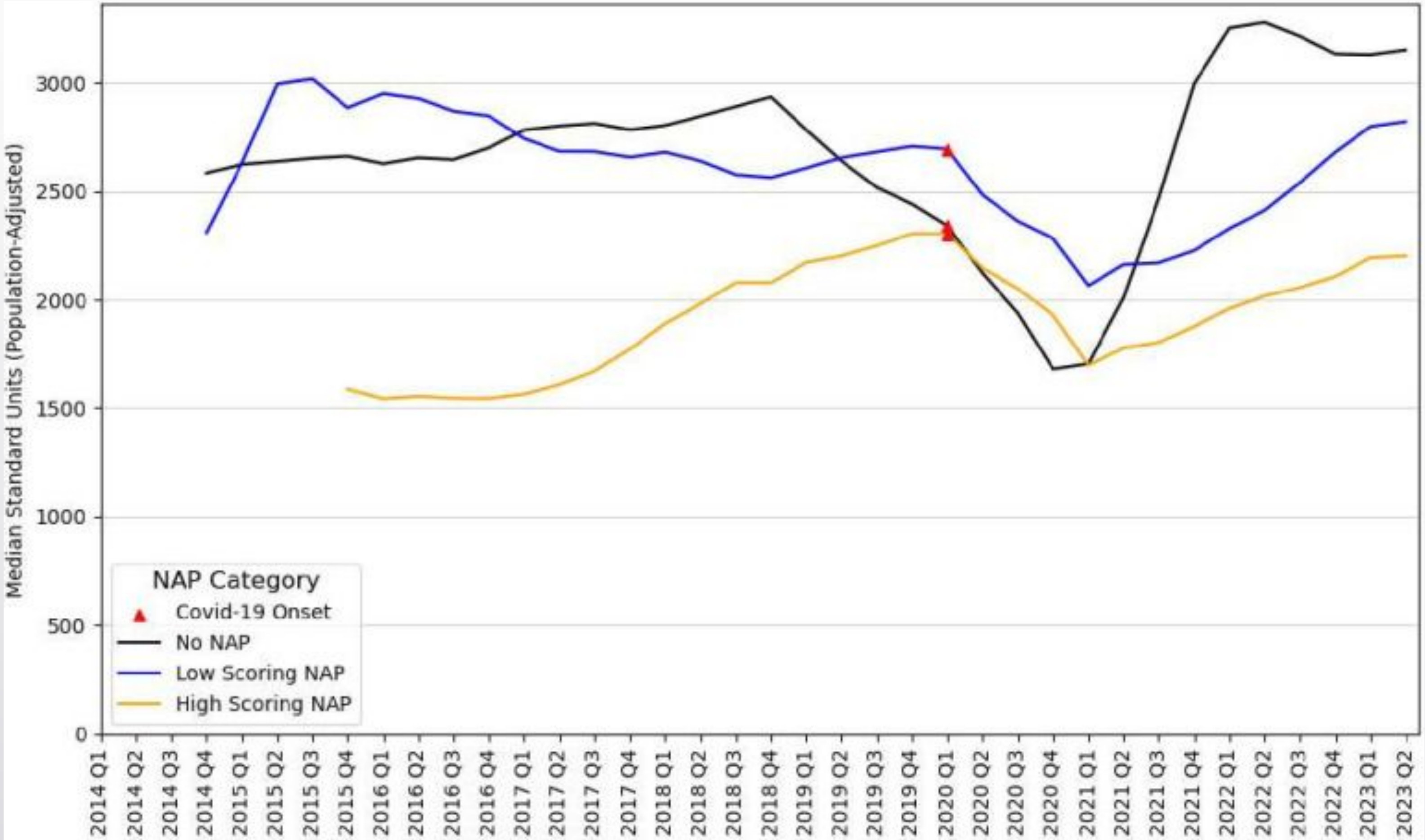
Specific Examples of Interventions

- Conduct training sessions
- Hand hygiene programme
- Controlling antibiotic prescriptions
- Integrating surveillance systems
- Raise public awareness
- Improve waste management

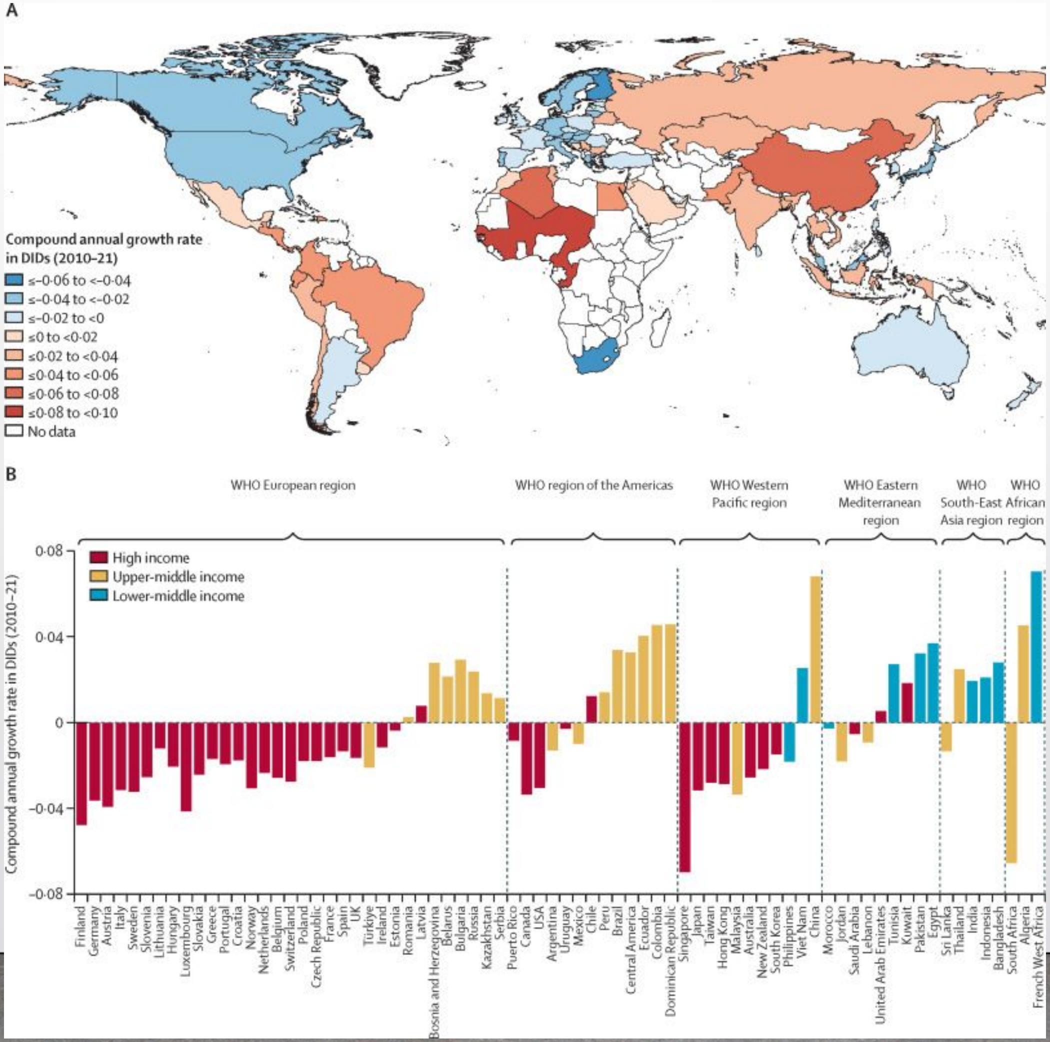
Possible Positive Outcomes

- Better Stewardship
- Improved IPC
- Reduction in antibiotic consumption
- Improved surveillance systems
- Reduced resistance rates

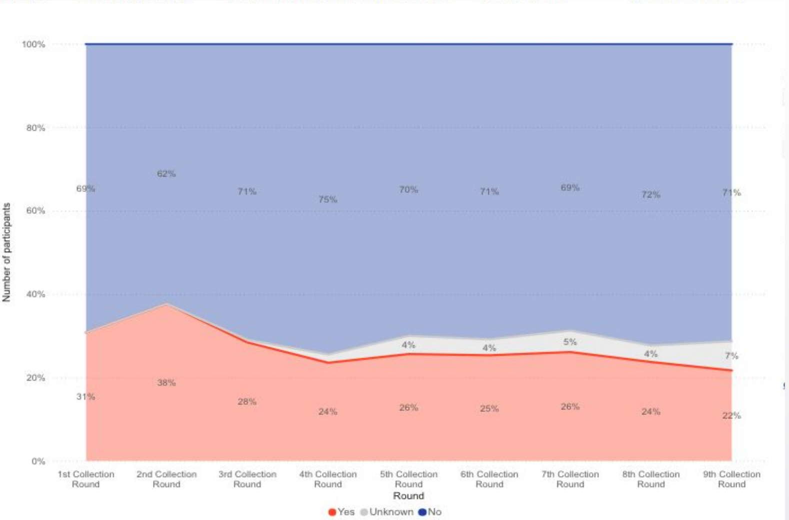
O’Neil 2025 report on Antimicrobial Use

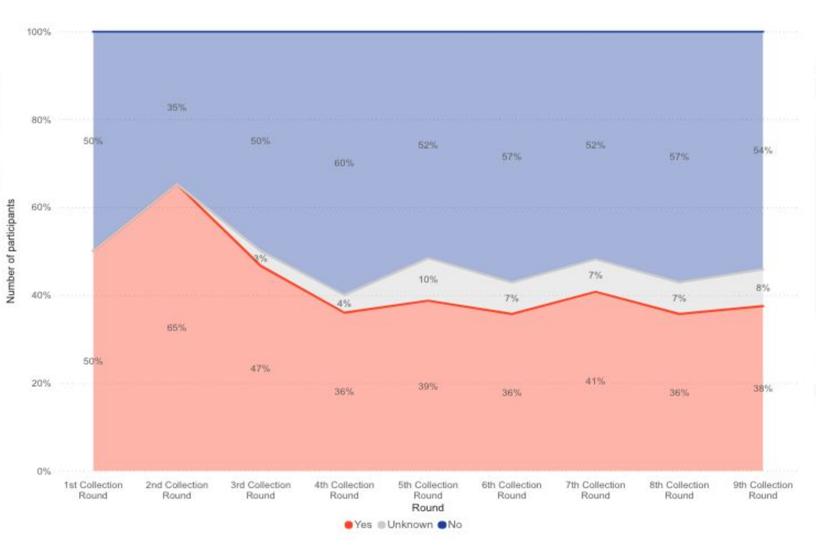


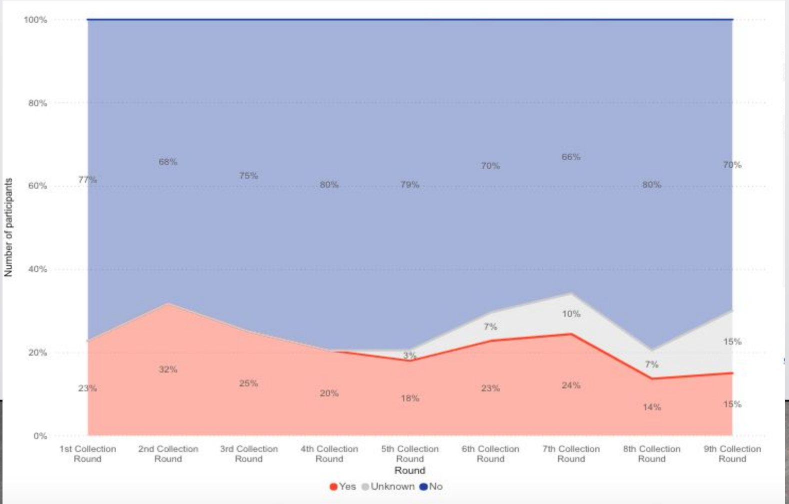
Median Standard Units (Population-Adjusted)
3000
2500
2000
1500
1000
500
0
NAP Category
Covid-19 Onset
No NAP
Low Scoring NAP
High Scoring NAP
2014 Q1
2014 Q2
2014 Q3
2014 Q4
2015 Q1
2015 Q2
2015 Q3
2015 Q4
2016 Q1
2016 Q2
2016 Q3
2016 Q4
2017 Q1
2017 Q2
2017 Q3
2017 Q4
2018 Q1
2018 Q2
2018 Q3
2018 Q4
2019 Q1
2019 Q2
2019 Q3
2019 Q4
2020 Q1
2020 Q2
2020 Q3
2020 Q4
2021 Q1
2021 Q2
2021 Q3
2021 Q4
2022 Q1
2022 Q2
2022 Q3
2022 Q4
2023 Q1
2023 Q2

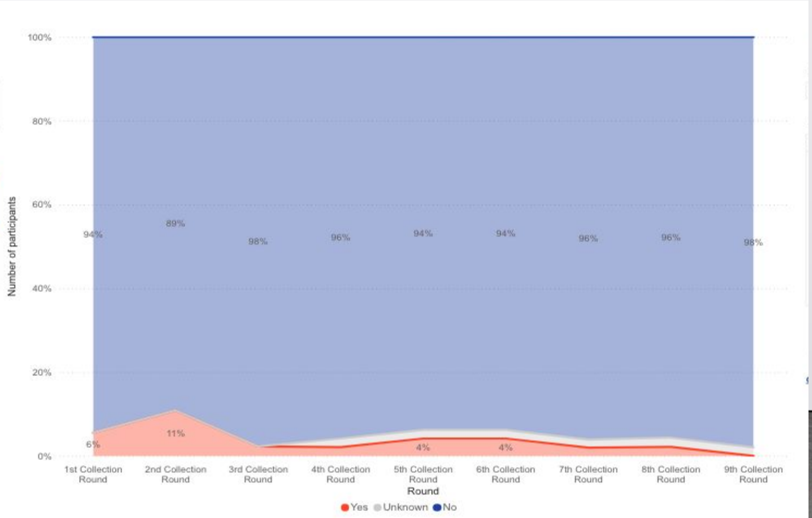

A
Compound annual growth rate in DIDs (2010–21)
≤–0·06 to <–0·04
≤–0·04 to <–0·02
≤–0·02 to <0
≤0 to <0·02
≤0·02 to <0·04
≤0·04 to <0·06
≤0·06 to <0·08
≤0·08 to <0·10
No data
B
WHO European region
WHO region of the Americas
WHO Western Pacific region
WHO Eastern Mediterranean region
WHO South-East Asia region
WHO African region
High income
Upper-middle income
Lower-middle income
Compound annual growth rate in DIDs (2010–21)
0·08
0·04
0
–0·04
–0·08
Finland
Germany
Austria
Italy
Sweden
Slovenia
Lithuania
Hungary
Luxembourg
Slovakia
Greece
Portugal
Croatia
Norway
Netherlands
Belgium
Switzerland
Poland
Czech Republic
France
Spain
UK
Türkiye
Ireland
Estonia
Romania
Latvia
Bosnia and Herzegovina
Belarus
Bulgaria
Russia
Kazakhstan
Serbia
Puerto Rico
Canada
USA
Argentina
Uruguay
Mexico
Chile
Peru
Brazil
Central America
Ecuador
Colombia
Dominican Republic
Singapore
Japan
Taiwan
Hong Kong
Malaysia
Australia
New Zealand
South Korea
Philippines
Viet Nam
China
Morocco
Jordan
Saudi Arabia
Lebanon
United Arab Emirates
Tunisia
Kuwait
Pakistan
Egypt
Sri Lanka
Thailand
India
Indonesia
Bangladesh
South Africa
Algeria
French West Africa

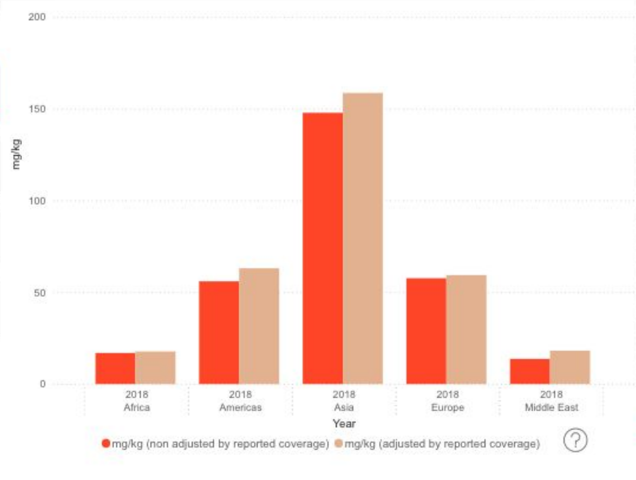
World Organisation for Animal Health Data

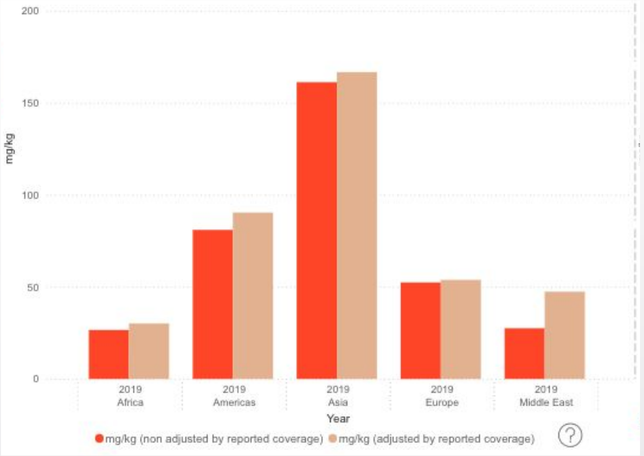

100%
80%
60%
40%
20%
0%
Number of participants
69% 62% 71% 75% 70% 71% 69% 72% 71%
4% 4% 5% 4% 7%
31% 38% 28% 24% 26% 25% 26% 24% 22%
1st Collection Round
2nd Collection Round
3rd Collection Round
4th Collection Round
5th Collection Round
6th Collection Round
7th Collection Round
8th Collection Round
9th Collection Round
Round
Yes Unknown No

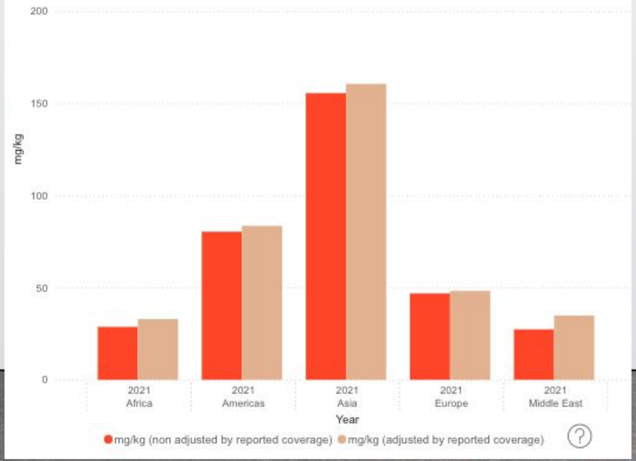

100%
80%
60%
40%
20%
0%
Number of participants
50% 35% 50% 60% 52% 57% 52% 57% 54%
3% 4% 10% 7% 7% 7% 8%
50% 65% 47% 36% 39% 36% 41% 36% 38%
1st Collection Round
2nd Collection Round
3rd Collection Round
4th Collection Round
5th Collection Round
6th Collection Round
7th Collection Round
8th Collection Round
9th Collection Round
Round
Yes Unknown No

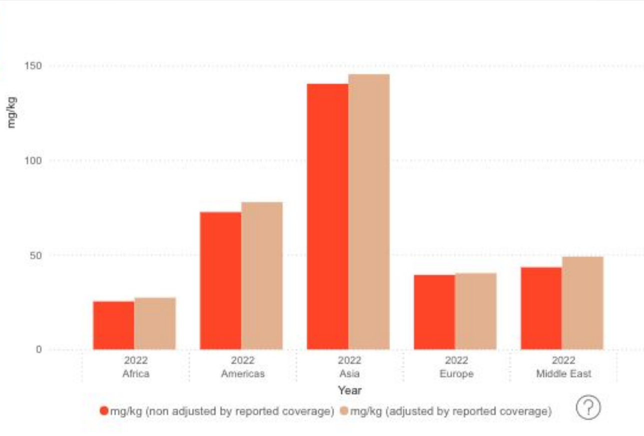

100%
80%
60%
40%
20%
0%
Number of participants
77% 68% 75% 80% 79% 70% 66% 80% 70%
3% 7% 10% 7% 15%
23% 32% 25% 20% 18% 23% 24% 14% 15%
1st Collection Round
2nd Collection Round
3rd Collection Round
4th Collection Round
5th Collection Round
6th Collection Round
7th Collection Round
8th Collection Round
9th Collection Round
Round
Yes Unknown No

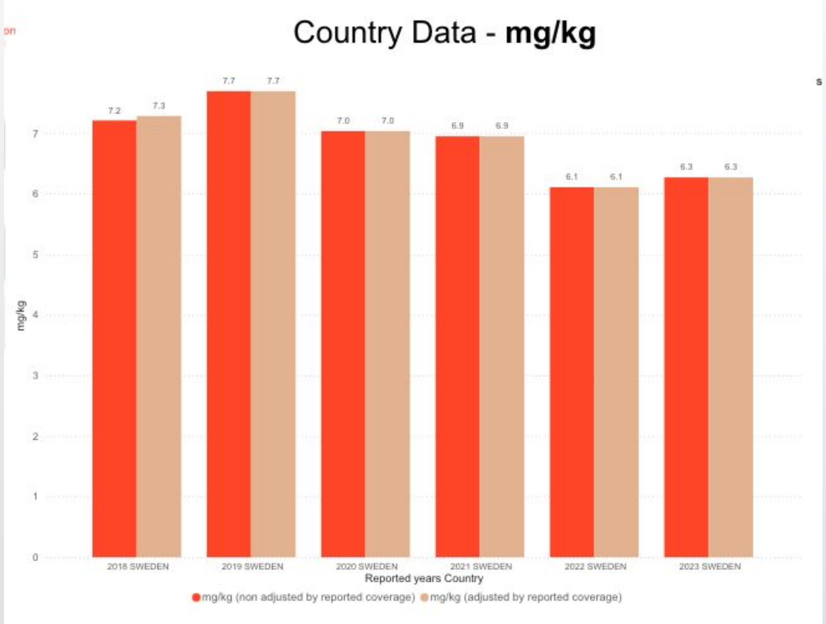

100%
80%
60%
40%
20%
0%
Number of participants
94% 89% 98% 96% 94% 94% 96% 96% 98%
6% 11% 4% 4%
1st Collection Round
2nd Collection Round
3rd Collection Round
4th Collection Round
5th Collection Round
6th Collection Round
7th Collection Round
8th Collection Round
9th Collection Round
Round
Yes Unknown No

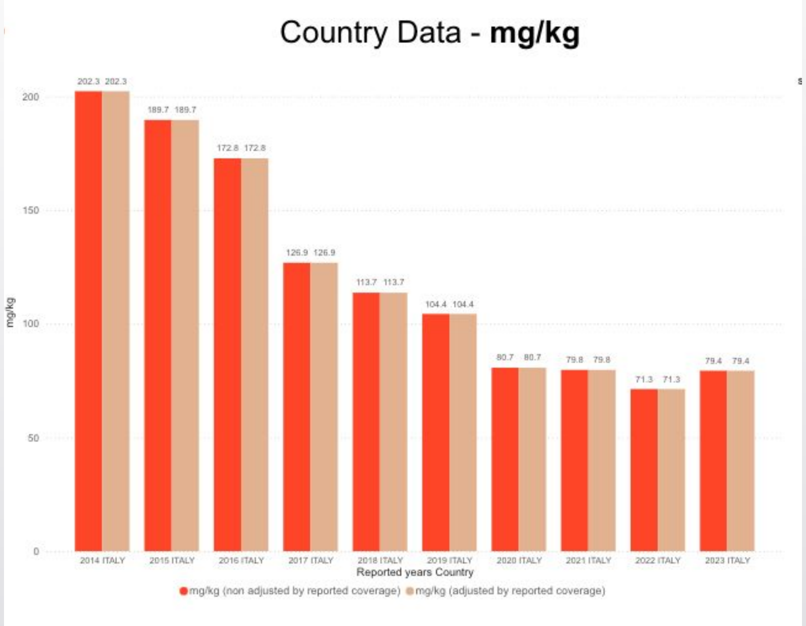

200
150
100
50
0
mg/kg
2018 Africa
2018 Americas
2018 Asia
2018 Europe
2018 Middle East
Year
mg/kg (non adjusted by reported coverage)
mg/kg (adjusted by reported coverage)


200
150
100
50
0
mg/kg
2019 Africa
2019 Americas
2019 Asia
2019 Europe
2019 Middle East
Year
mg/kg (non adjusted by reported coverage)
mg/kg (adjusted by reported coverage)


200
150
100
50
0
mg/kg
2021 Africa
2021 Americas
2021 Asia
2021 Europe
2021 Middle East
Year
mg/kg (non adjusted by reported coverage)
mg/kg (adjusted by reported coverage)


150
100
50
0
mg/kg
2022 Africa
2022 Americas
2022 Asia
2022 Europe
2022 Middle East
Year
mg/kg (non adjusted by reported coverage)
mg/kg (adjusted by reported coverage)


Country Data - mg/kg
7.2
7.3
7.7
7.7
7.0
7.0
6.9
6.9
6.1
6.1
6.3
6.3
mg/kg
2018 SWEDEN
2019 SWEDEN
2020 SWEDEN
2021 SWEDEN
2022 SWEDEN
2023 SWEDEN
Reported years Country
mg/kg (non adjusted by reported coverage)
mg/kg (adjusted by reported coverage)


Country Data - mg/kg
202.3 202.3
189.7 189.7
172.8 172.8
126.9 126.9
113.7 113.7
104.4 104.4
80.7 80.7
79.8 79.8
71.3 71.3
79.4 79.4
mg/kg
2014 ITALY
2015 ITALY
2016 ITALY
2017 ITALY
2018 ITALY
2019 ITALY
2020 ITALY
2021 ITALY
2022 ITALY
2023 ITALY
Reported years Country
mg/kg (non adjusted by reported coverage)
mg/kg (adjusted by reported coverage)

AMR Success Stories

The Story of Sweden

The Gains

- Antibiotic Growth Promoters banned
- Restriction on use of key human antibiotics
- Reduction in occurrence of PRSA (10% to 1%)

The Process

- Active infection control and disease eradication in animals
- Zero tolerance of any contamination by key pathogens
- Established key legislation
- Control of Bacteria with Specific Resistance
- Data generation and dissemination
- Surveillance

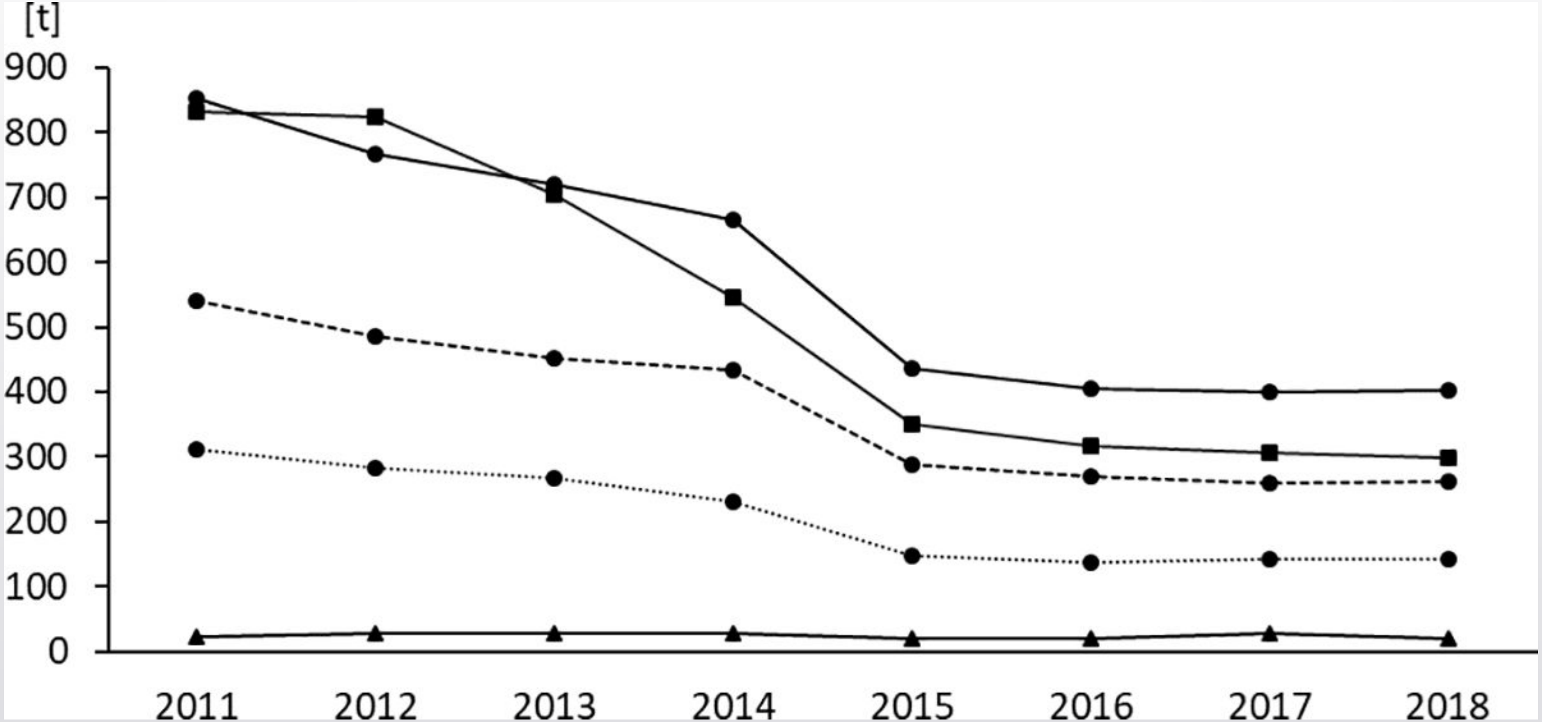
Reduction of Veterinary Antimicrobial Use in Germany

year	volume [t]	change [%]
2011	1705.659	
2012	1619.039	-5.08
2013	1451.619	-10.34
2014	1238.340	-14.69
2015	805.281	-34.97
2016	742.258	-7.83
2017	733.108	-1.23
2018	722.430	-1.46
total	**-983.229**	**-57.65**

Volumes represent the total quantities of active ingredient sold in tons [t] within the given year. Changes expressed in percent relate to the sales volumes of the previous year.

https://doi.org/10.1371/journal.pone.0237459.t002

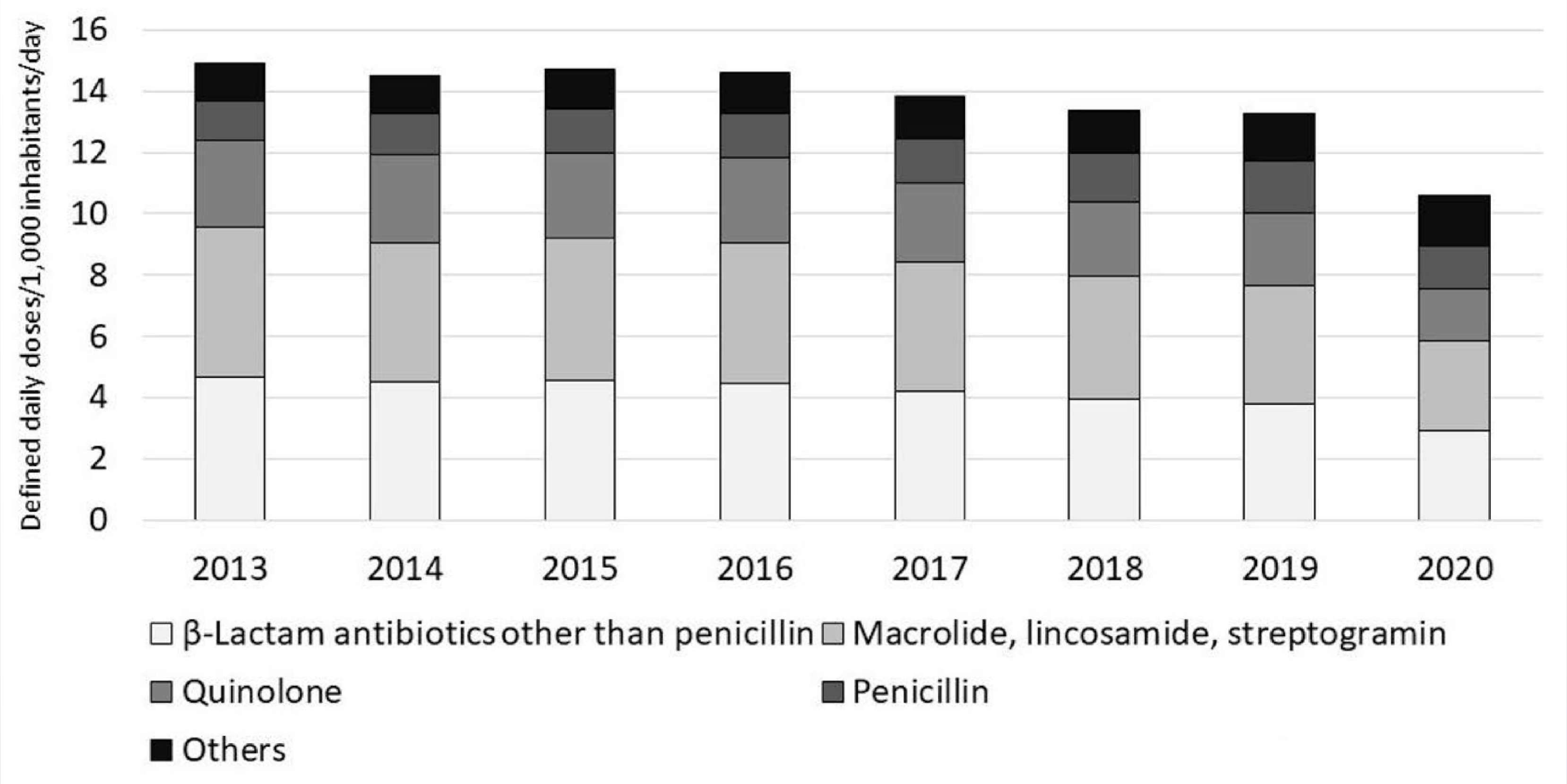
Reduction of Veterinary Antimicrobial Use in Germany



The Story of Japan - Process

- Compilation of a Manual of Antimicrobial Stewardship
- Surveillance and monitoring
- Public awareness and campaigns
- Infection Prevention and Control
- Research and Development

The Story of Japan - Outcome


Defined daily doses/1,000 inhabitants/day
16
14
12
10
8
6
4
2
0
2013
2014
2015
2016
2017
2018
2019
2020
β-Lactam antibiotics other than penicillin
Macrolide, lincosamide, streptogramin
Quinolone
Penicillin
Others

Resistance Rate to Antimicrobials in Bacterial Isolates			
Indices	**2013**	**2020**	**Targets**
Insensitive rate to penicillin in *Streptococcus pneumoniae* isolates	47.4%	33.3%	≤15%
Resistance rate to fluoroquinolones in *Escherichia coli* isolates	35.5%	41.5%	≤25%
Resistance rates to methicillin in *Staphylococcus aureus* isolates	51.1%	47.5%	≤20%
Resistance rates to carbapenem in *Pseudomonas aeruginosa* isolates	10.7–17.1%	10.5–15.9%	≤10%
Resistance rates to carbapenems in *E. coli* and *Klebsiella pneumoniae* isolates	0.1–0.6%	0.1–0.4%	≤0.2% (similar level)
Use of Antimicrobials (Defined Daily Doses per 1000 Inhabitants per Day)			
Indices	**2013**	**2020 (vs. 2013 Level)**	**Targets**
Total	14.91	Reduction by 28.9%	≤2/3 (vs. 2013 level)
Oral cephalosporins, fluoroquinolones, and macrolides	3.91, 2.83, and 4.83, respectively	Oral cephalosporins Reduction by 42.8% Oral fluoroquinolones Reduction by 41.5% Oral macrolides Reduction by 39.5%	Reduction by 50% (vs. 2013 level)
Intravenous antimicrobials	0.96	Reduction by 2.7%	Reduction by 20% (vs. 2013 level)

Prepared based on Refs. [6,24,26,27].

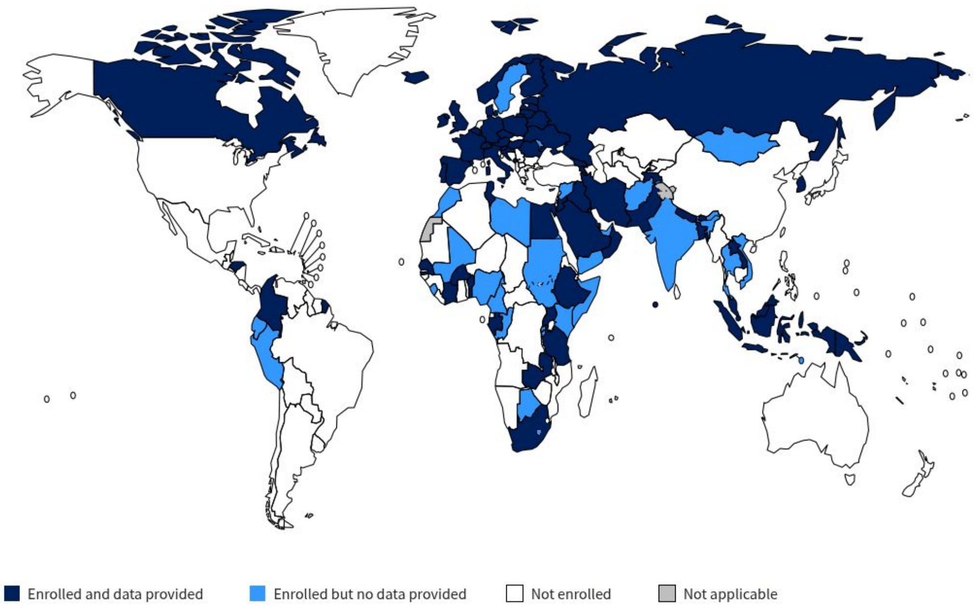
India Success Stories

- Pre-policy (2011–2014): 872 • Post-policy (2015–2017): 698 • Number of reserved drug prescriptions reduced by 174 prescriptions
- Decreased by 32%, from 574 to 390 per 1000 patient-days (P <0.01)
- Antibiotic exposure: Significant reduction from 75% to 41%
- **Antibiotic use**: Reduced significantly from 3.9 vials per admission in 2011-2012 to 2.36 vials per admission in 2014-2015, indicating a 40% reduction
  Antibiotic use over 4 years: Antibiotic use significantly reduced, from 10,545 vials in 2011-2012 to 7446 vials in 2014-2015
- **Proportion of prescriptions with inappropriate antibiotic use**: Declined steadily they were 77.6%, 70.3%, and 58.6% in the baseline, intervention, and follow-up phases, respectively

GLASS: Global Antimicrobial Resistance and Use Surveillance System

- A child of the WHO Global Action Plan to tackle AMR (GAP-AMR initiative)
- Focused on addressing the issue of “Surveillance”
- Launched on the 22nd of October 2015
- Provides a standardized approach to the collection, analysis, interpretation and sharing of data by countries
- Seeks to actively support capacity building and monitor the status of existing and new national surveillance systems
- Designed to evolve to incorporate data from surveillance of AMR in humans and the use of antimicrobial medicines in the food chain and in the environment

Global AMU Map



Global Antimicrobial Resistance and Use Surveillance System (GLASS): Last updated on 25 September 2025, with 2016-2023 data (submitted by end of 2024)

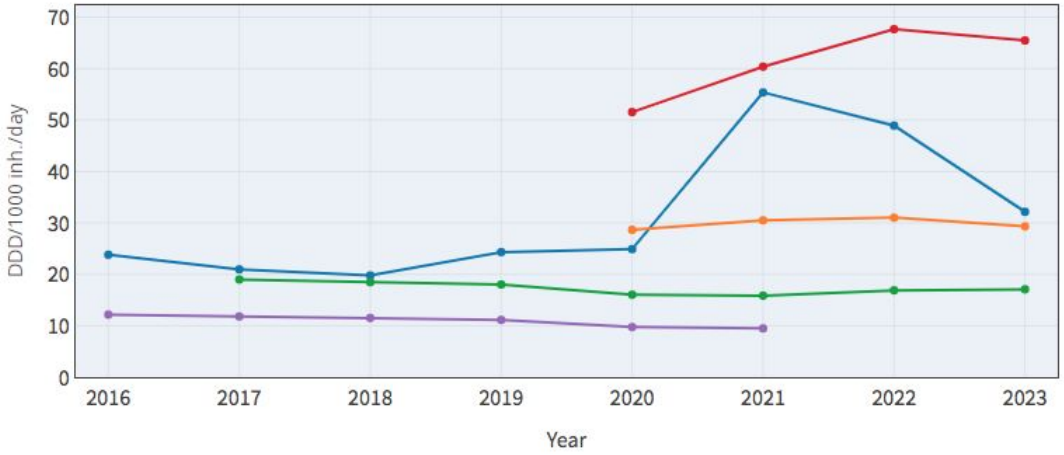
Downloaded on 17 November 2025 from worldhealthorg.shinyapps.io/glass-dashboard/

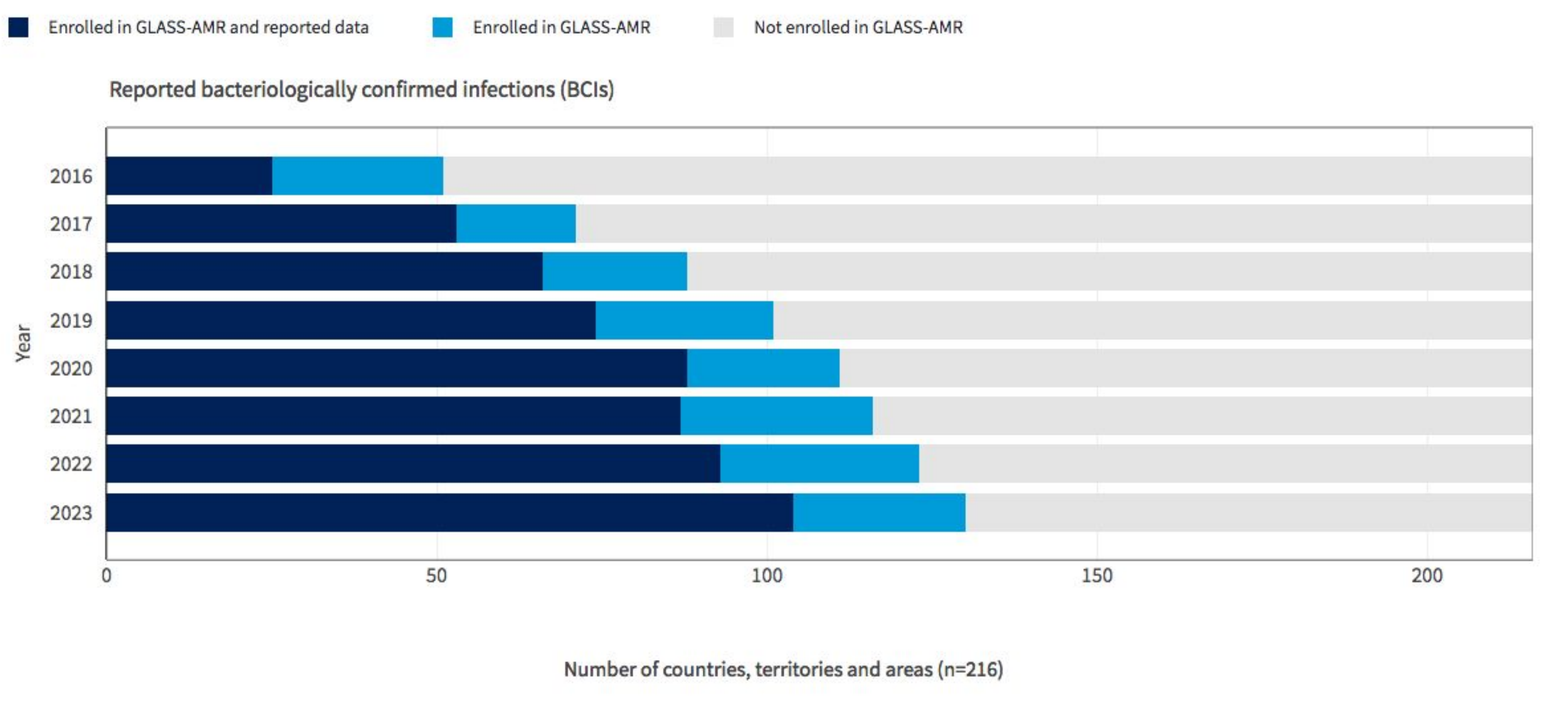
World Health Organization

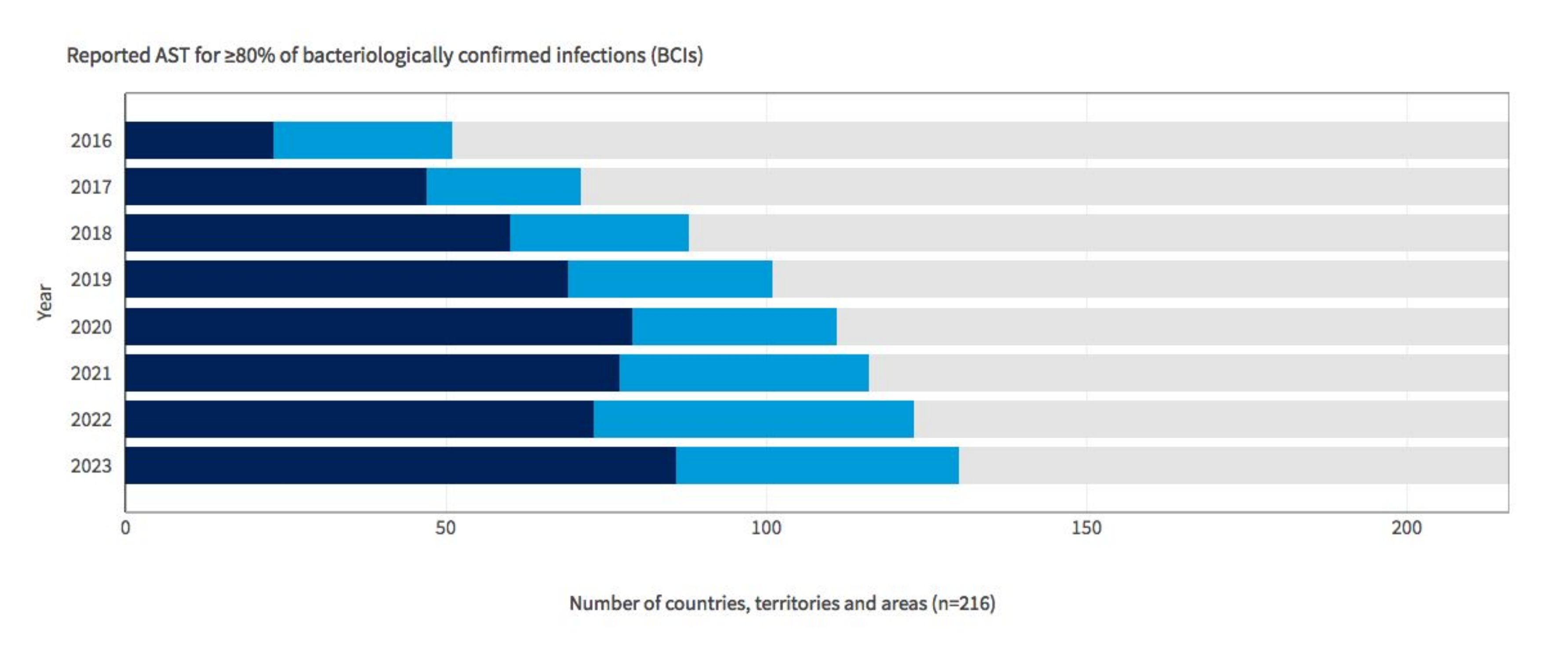
Select CTA (max. 5)

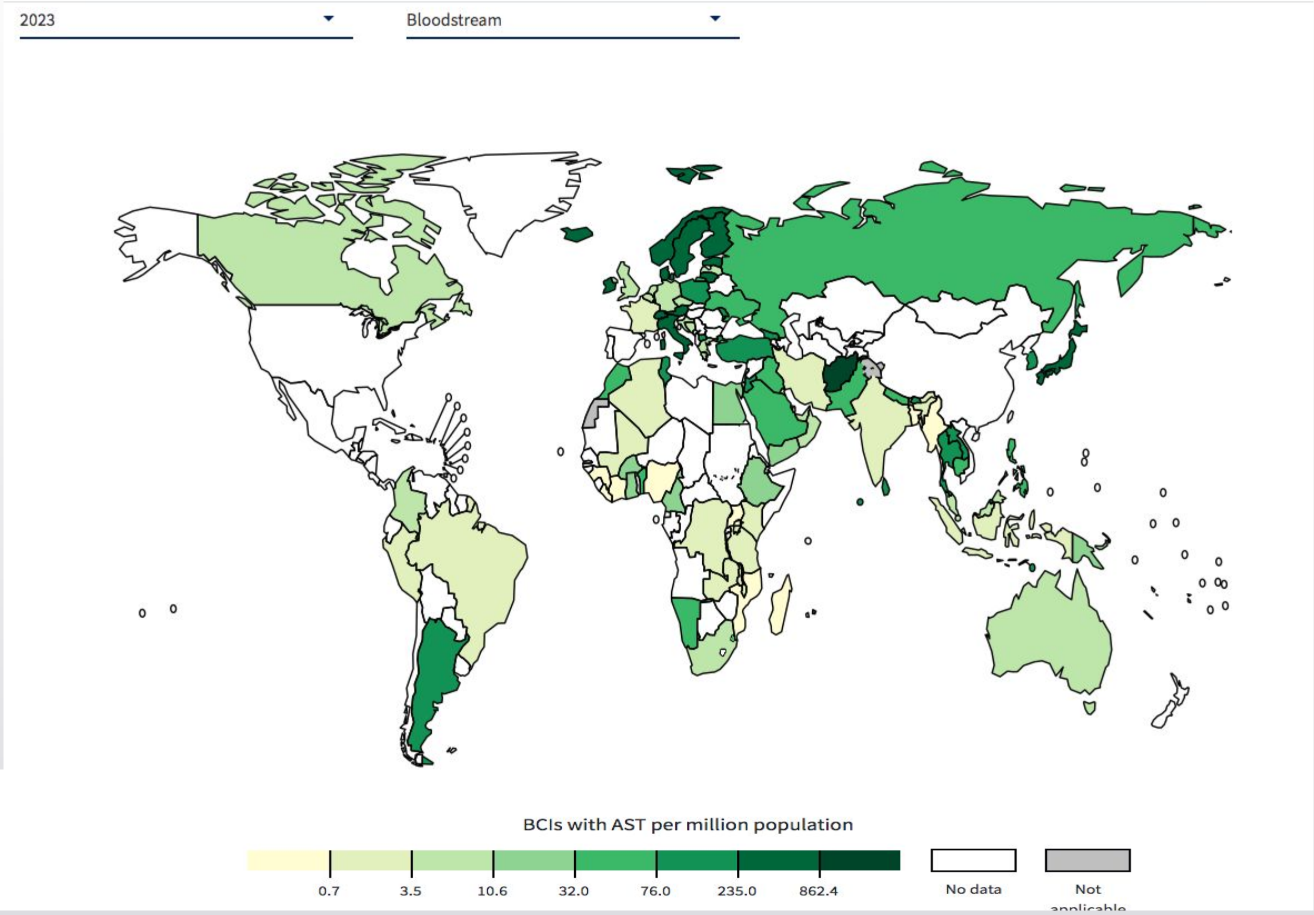
5 options selected

- Bangladesh
- Egypt
- United Kingdom of Great Britain and Northern Ireland[a,b,c,d,e,f,g]
- Iran (Islamic Republic of)
- Sweden




Enrolled in GLASS-AMR and reported data
Enrolled in GLASS-AMR
Not enrolled in GLASS-AMR
Reported bacteriologically confirmed infections (BCIs)
Year
2016
2017
2018
2019
2020
2021
2022
2023
0
50
100
150
200
Number of countries, territories and areas (n=216)


Reported AST for ≥80% of bacteriologically confirmed infections (BCIs)
Year
2016
2017
2018
2019
2020
2021
2022
2023
0
50
100
150
200
Number of countries, territories and areas (n=216)



2023
Bloodstream
BCIs with AST per million population
0.7
3.5
10.6
32.0
76.0
235.0
862.4
No data
Not applicable

2020

All

Country	Total BCIs per million population	Absolute number of BCIs	Total BCIs with AST per million population	Absolute number of BCIs with AST	% of BCIs with AST
Mozambique	2.3	72	2.3	71	98.6
Myanmar	15.9	845	15.1	799	94.6
Nepal	52.3	1515	35.0	1015	67.0
Netherlands (Kingdom of the)	712.5	12 566	712.5	12 566	100.0
Nigeria	0.7	160	0.7	145	90.6
North Macedonia	156.5	293	156.0	292	99.7
Norway	1073.4	5774	1073.4	5774	100.0
Oman	193.7	876	124.9	565	64.5
Pakistan	23.9	5623	11.5	2697	48.0
Peru	24.1	793	24.1	791	99.7

Previous 1 … 5 6 7 8 9 Next

[a]All references to Kosovo should be understood to be in the context of the United Nations Security Council resolution 1244 [1999]. Data from Kosovo are not shown on the

2022

Country	Total BCIs per million population	Absolute number of BCIs	Total BCIs with AST per million population	Absolute number of BCIs with AST	% of BCIs with AST
Malta	1336.6	706	1334.7	705	99.9
Mauritius	1022.6	1305	1021.1	1303	99.8
Morocco	27.2	1016	21.5	803	79.0
Mozambique	2.4	80	2.4	80	100.0
Myanmar	1.1	60	1.1	57	95.0
Namibia	72.0	208	69.9	202	97.1
Nepal	95.2	2829	49.2	1462	51.7
Netherlands (Kingdom of the)	723.5	12 954	723.5	12 954	100.0
Nigeria	0.8	187	0.6	132	70.6
North Macedonia	151.6	279	148.9	274	98.2

Previous 1 … 5 6 7 … 10 Next

[a]All references to Kosovo should be understood to be in the context of the United Nations Security Council resolution 1244 [1999]. Data from Kosovo are not shown on the map.

2023

Country	Total BCIs per million population	Absolute number of BCIs	Total BCIs with AST per million population	Absolute number of BCIs with AST	% of BCIs with AST
Mauritius	1217.8	1551	1217.0	1550	99.9
Morocco	41.6	1569	39.6	1494	95.2
Mozambique	1.5	51	1.5	50	98.0
Myanmar	2.4	130	2.3	122	93.8
Namibia	42.5	126	34.1	101	80.2
Nepal	92.3	2740	65.7	1950	71.2
Netherlands (Kingdom of the)	649.3	11 748	649.3	11 748	100.0
Nigeria	1.3	302	1.0	228	75.5
North Macedonia	154.5	283	154.5	283	100.0
Norway	1089.8	6015	1089.8	6015	100.0

Previous 1 … 6 7 8 9 10 Next

[a]All references to Kosovo should be understood to be in the context of the United Nations Security Council resolution 1244 [1999]. Data from Kosovo are not shown on the map.

Country Comparison for MRSA (isolated from BSI)

Country	Year	Total Isolates	Interpretable AST	Resistant	% Resistant
Sweden	2018	10849	3639	70	1.92360539
Sweden	2019	18598	5948	107	1.79892401
Sweden	2020	38574	13742	320	2.32862757
Sweden	2021	21163	7733	152	1.96560197
Sweden	2022	21788	7936	147	1.85231855
Sweden	2023	21978	7915	168	2.12255212
Argentina	2018	7385	1877	850	45.2850293
Argentina	2019	5783	1494	628	42.0348059
Argentina	2020	7376	1604	616	38.40399
Argentina	2021	9243	1841	632	34.3291689
Argentina	2022	8366	1833	601	32.7877796
Argentina	2023	9290	2257	806	35.711121

WHO Recommendations

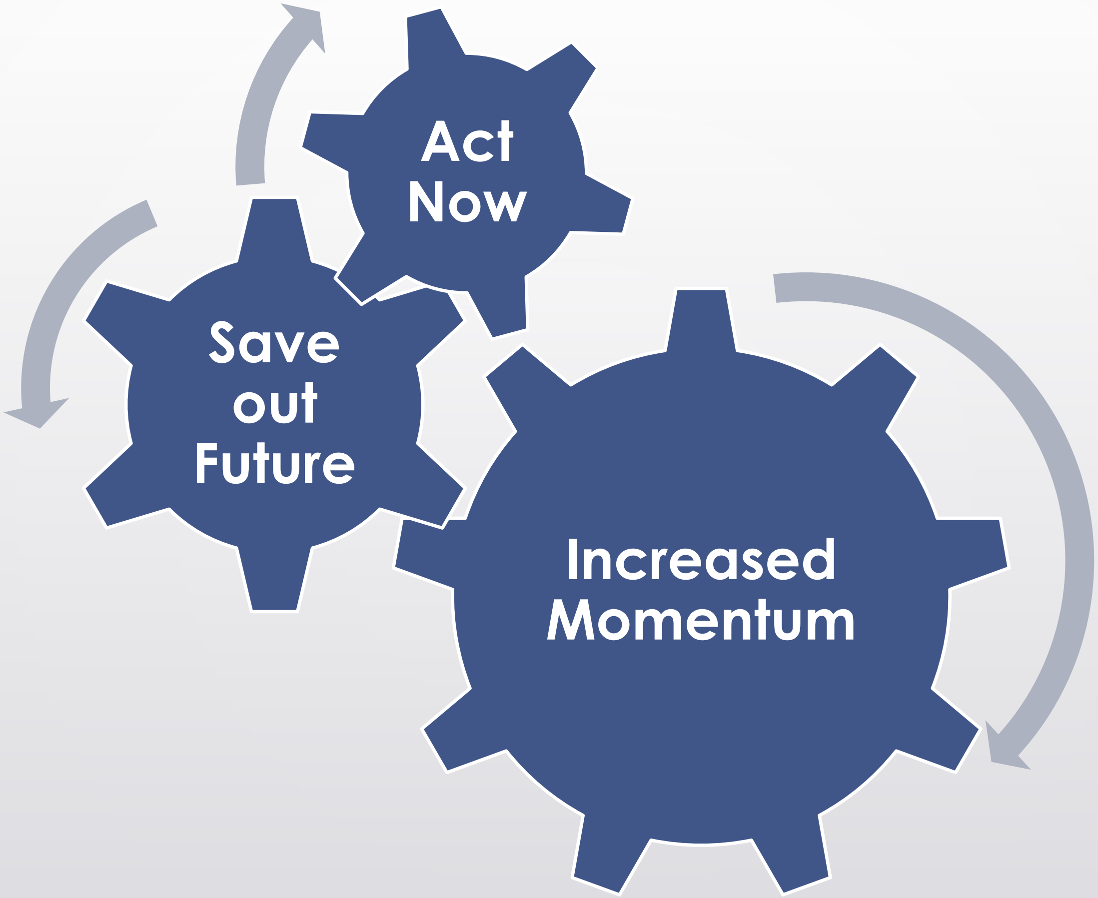
- Antimicrobial leadership
- Training and education for health service providers and patients
- Development of antimicrobial guidelines and protocols
- Feedback on antibiotics use
- Reporting
- Accountability and responsibility

Nigeria: Current Situation

- Nigeria NAP established
  - Currently on NAP 2.0
- Two national reference laboratories selected
- Ten laboratories engaged to participate in the National Antimicrobial Resistance Surveillance System
- Standardised operating procedures (SOPs) for laboratories participating in the AMR surveillance developed
- Engagement with GLASS

Nigeria: Take Home Lesson

- Political Will
- Improved funding
- Multisectoral/Multifaceted Collaboration
- Expansion of current programmes
- Massive awareness campaigns in all sectors


Act Now
Save out Future
Increased Momentum

THANK YOU FOR LISTENING

Harnessing Artificial Intelligence for AMR Surveillance in Nigeria

Ugonna C. Morikwe

Ph.D. Candidate, Applied Science and Technology, North Carolina Agricultural and Technical State University, USA.

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North Carolina Agricultural and Technical State University, USA.

Harnessing Artificial Intelligence for Antimicrobial Surveillance in Nigeria

Act Now: Protect Our Present, Secure Our Future

Ugonna Morikwe, PhD
North Carolina A&T State University
NSF Engineering Research Center for Precision Microbiome Engineering (PreMiEr)

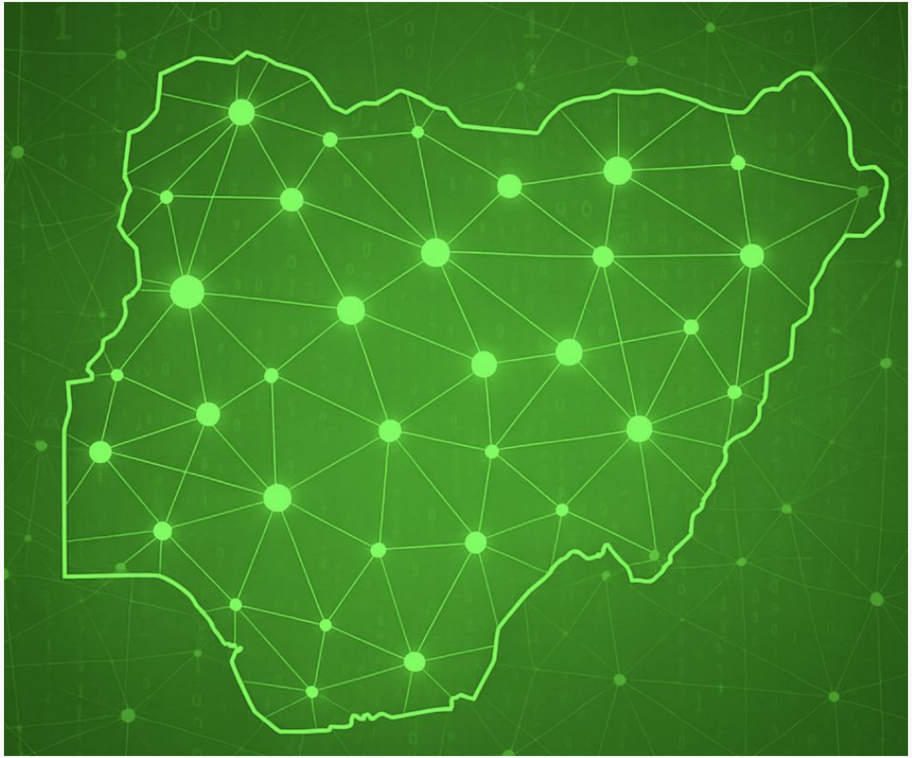
Duke | North Carolina Agricultural and Technical State University | NC State University | The University of North Carolina at Chapel Hill | University of North Carolina Charlotte | NSF

PreMiEr Precision Microbiome Engineering
NSF Engineering Research Center

ucmorikwe@aggies.ncat.edu

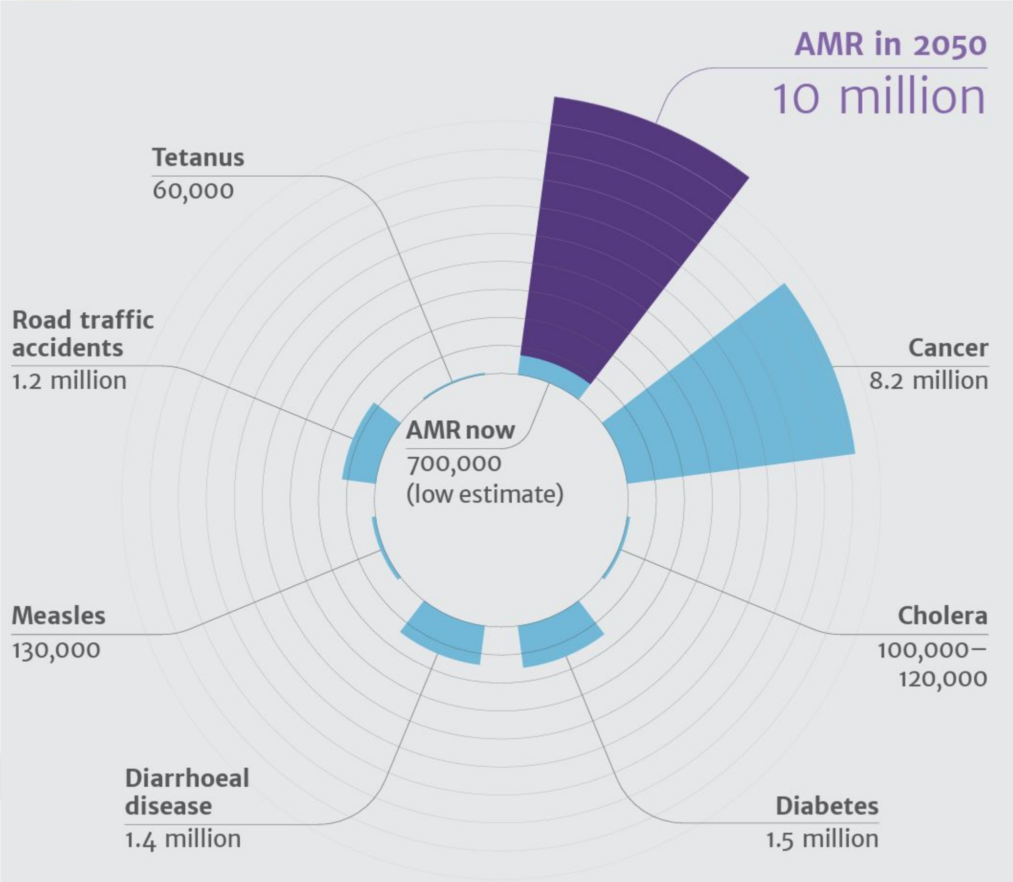
November 20, 2025

How can AI and data science strengthen Nigeria's AMR surveillance



…and inform actionable public health strategies?

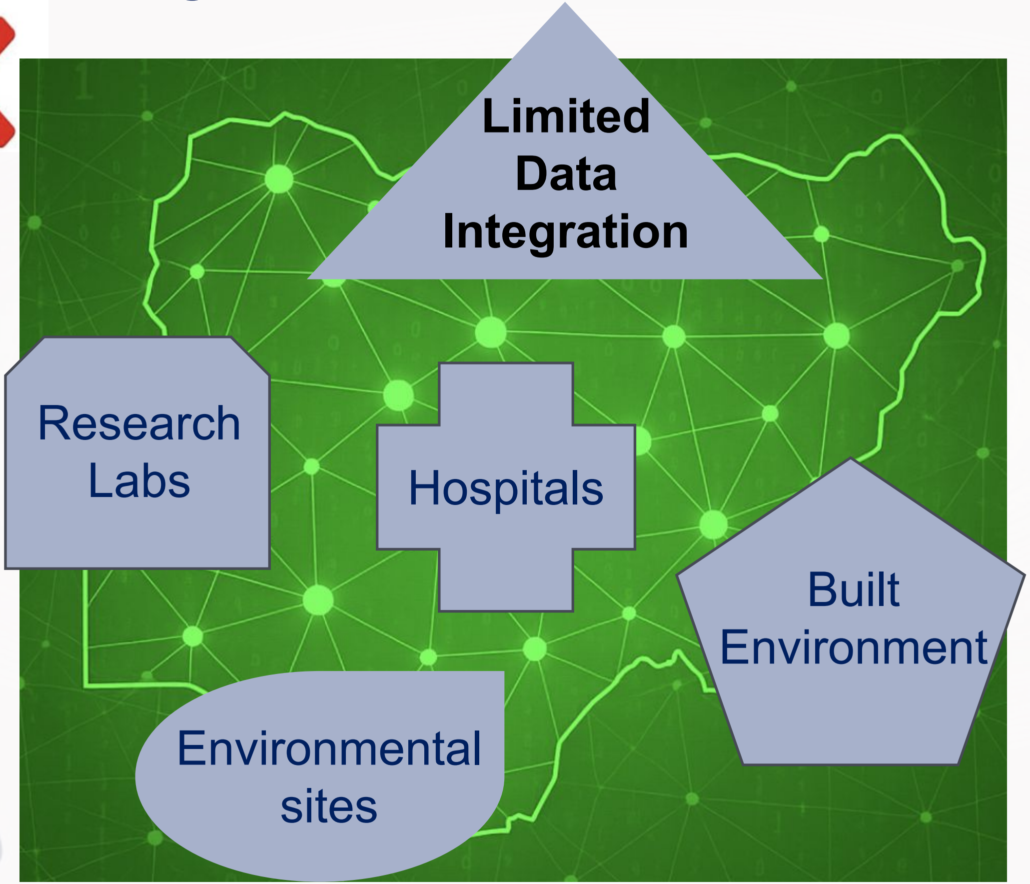
AMR: The Global and Nigerian Picture



- 1.27 million deaths annually (global)
- Highest burden in Sub-Saharan Africa
- High antimicrobial consumption in Nigeria
- Weak genomic data integration

J. O'Neill; 2014
Murray et al, The Lancet 2022
WHO GLASS Report 2024

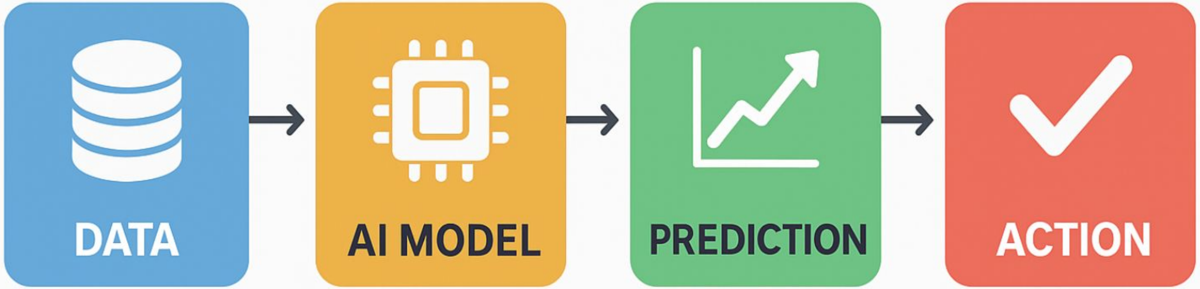
Gaps in Nigeria's AMR Surveillance Landscape



- Environmental surveillance e.g., wastewater, community settings is sparse
- Fragmented systems
- Missing early warning signals
- Environmental reservoirs are under characterized
- AI offers predictive capability beyond traditional surveillance

Why AI Matters

AI learns from data to detect, predict, and guide action

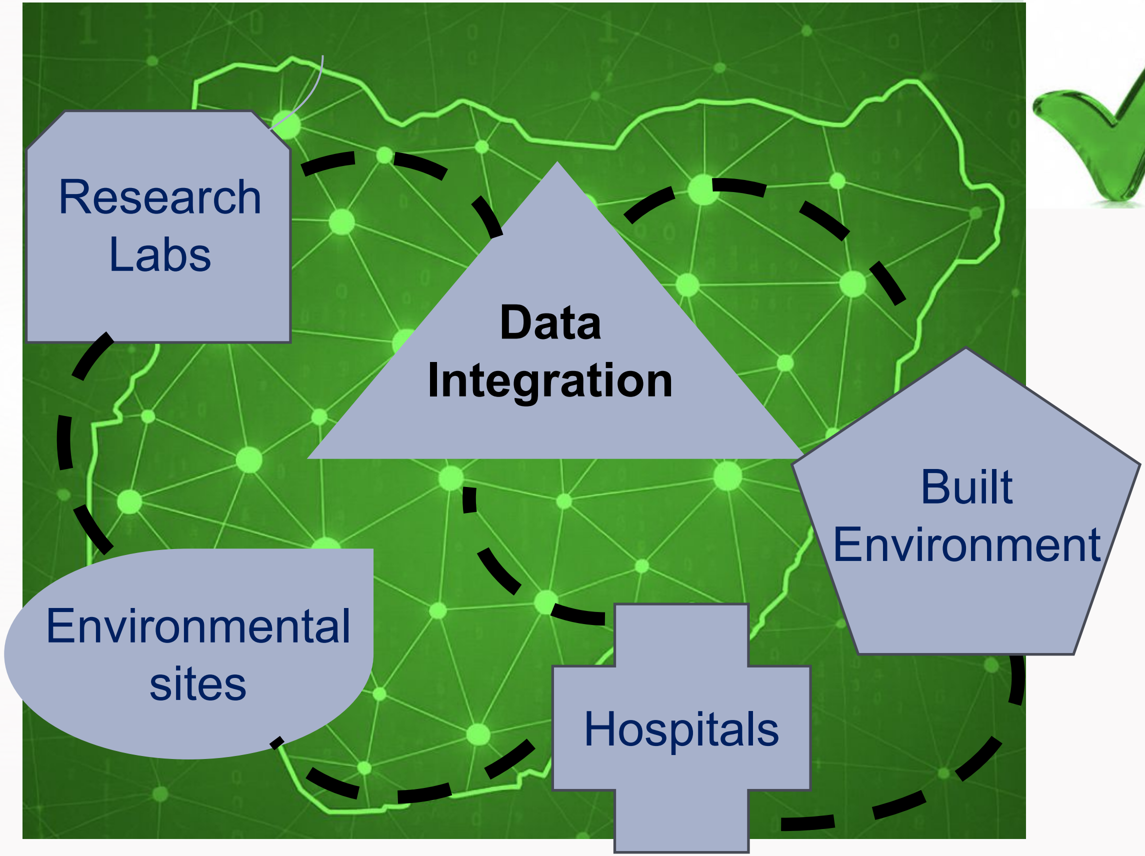


- **Machine Learning**: predicts resistance trends
- **NLP**: extracts insights from unstructured clinical reports
- **Computer Vision**: automates lab plate and microscopy analysis
- Example: ML prediction of carbapenem resistance

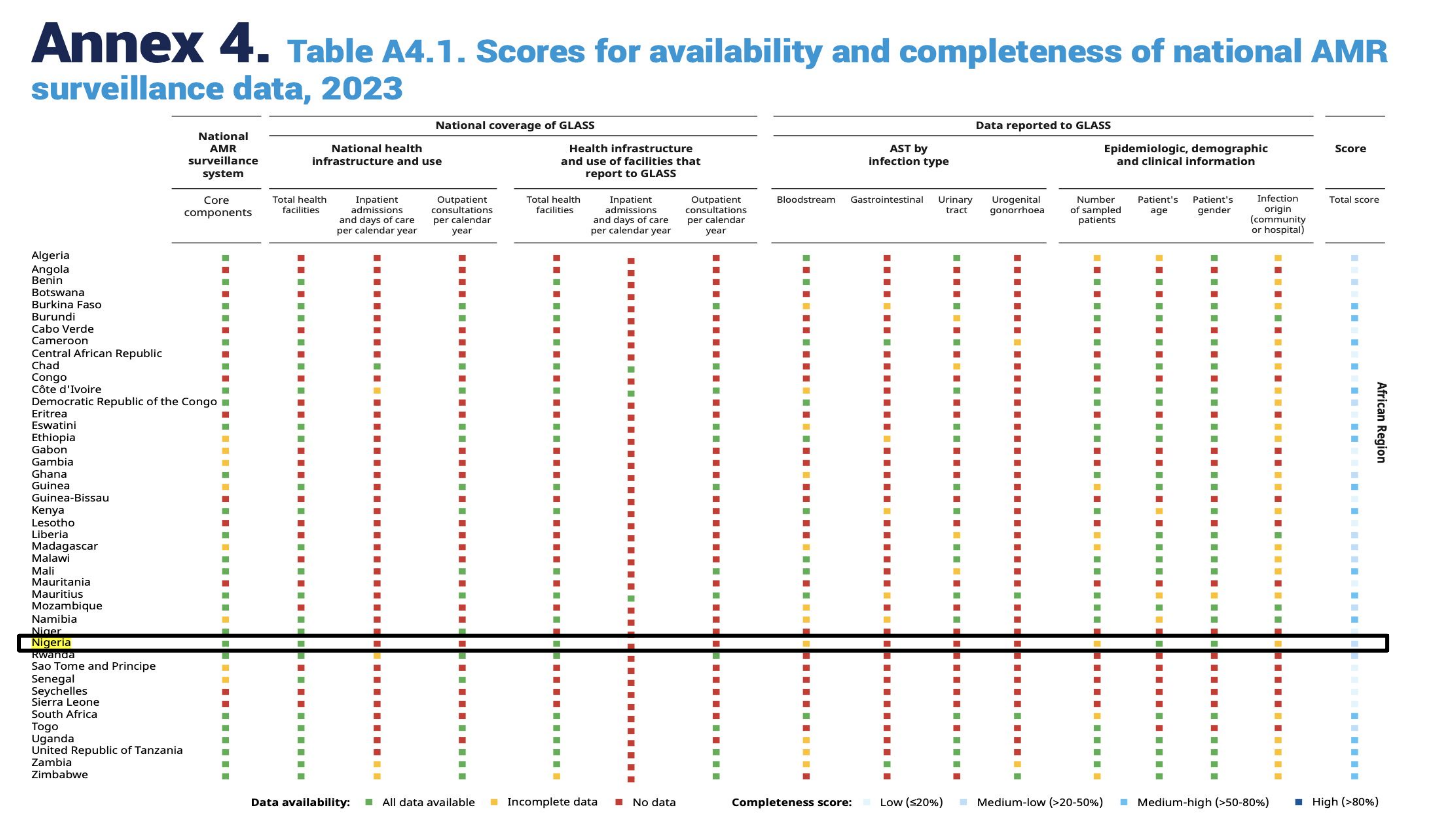
Arango-Argoty et al., Sci Rep 2018

Data Integrated Systems

- Unify clinical, environmental, and genomic data into AI-ready datasets
- Early warning systems
- Strengthen public health decisions
- Integration with national GLASS reporting infrastructure



Nigeria: AMR Surveillance Completeness, GLASS 2025



WHO Global Antimicrobial Resistance and Use Surveillance System (GLASS), 2025

PreMiEr Precision Microbiome Engineering
NSF Engineering Research Center

Nigeria: AMR Surveillance Completeness, GLASS 2025

Annex 4. Table A4.1. Scores for availability and completeness of national AMR surveillance data, 2023

	National AMR surveillance system	National coverage of GLASS						Data reported to GLASS								Score
		National health infrastructure and use			Health infrastructure and use of facilities that report to GLASS			AST by infection type				Epidemiologic, demographic and clinical information				
	Core components	Total health facilities	Inpatient admissions and days of care per calendar year	Outpatient consultations per calendar year	Total health facilities	Inpatient admissions and days of care per calendar year	Outpatient consultations per calendar year	Bloodstream	Gastrointestinal	Urinary tract	Urogenital gonorrhoea	Number of sampled patients	Patient's age	Patient's gender	Infection origin (community or hospital)	Total score
Nigeria																

Data availability: All data available · Incomplete data · No data

Completeness score: Low (≤20%) · Medium-low (>20-50%) · Medium-high (>50-80%) · High (>80%)

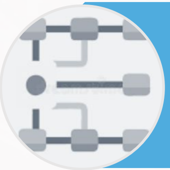
Surveillance data is critical.

WHO Global Antimicrobial Resistance and Use Surveillance System (GLASS), 2025

Environmental AMR Surveillance: My Scientific Foundation

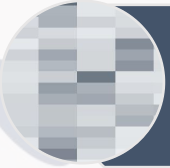
Environmental sampling across wastewater, household surfaces, and built environment

Pathogen and ARG detection using shotgun metagenomics (Illumina, Oxford Nanopore), ddPCR



End-to-end bioinformatics workflows:

QC → assembly → ARG annotation



Linking environmental AMR signals to

Community antibiotic use and risk patterns

Post-data Processing: AI co-pilot tools can help Nigerian labs rapidly build, adapt, and debug R-based workflows, reducing technical bottlenecks in AMR data processing

Post-Data Processing: AI Co-Pilot Tools for Nigerian Labs

A major bottleneck in Nigeria is **bioinformatics capacity**

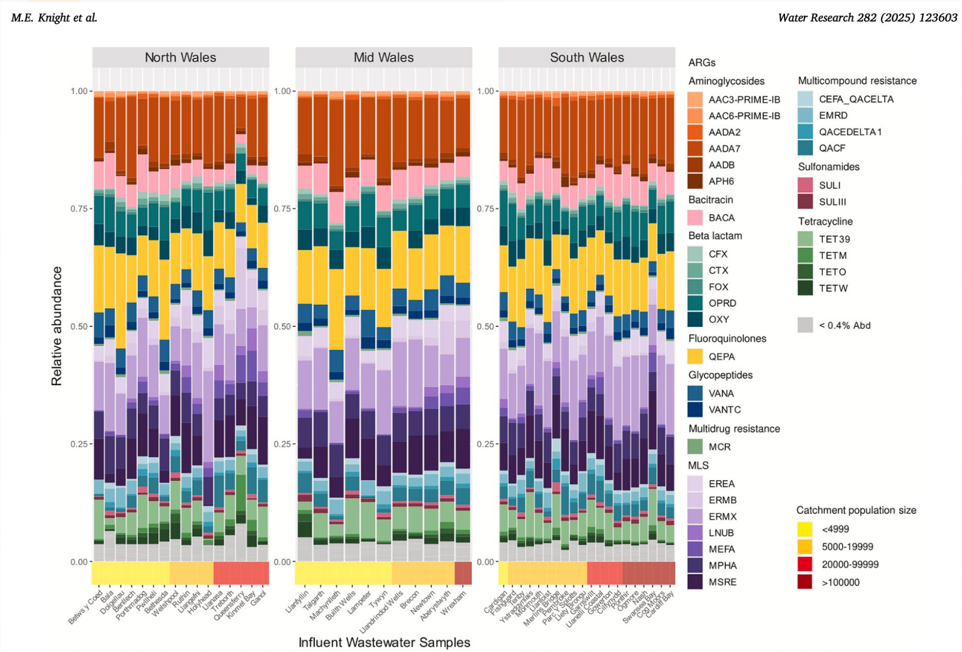
Many labs collect data but struggle with **processing, analysis, and interpretation**

AI co-pilot tools can help labs: build R-based workflows, Debug pipelines, automate QC and analyze, standardize outputs

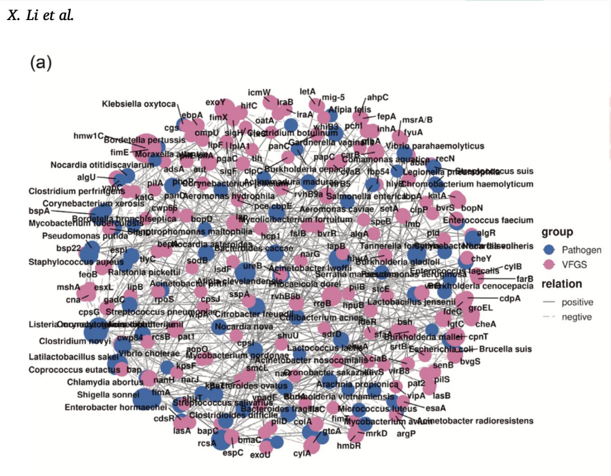
This reduces delays and empowers labs to contribute to national AMR surveillance

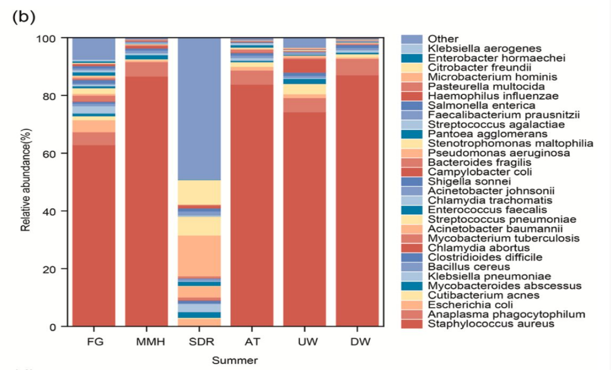
Open-source tools: ResFinder, Galaxy workflows, AMR++, AMRFinderPlus

Wastewater AMR Signals Reveal Hidden Community Trends



Nigeria likely reflects these trends, but national data are incomplete, hence these trends are missed, which is why AI-enabled integrated surveillance is needed





M.E. Knight et al. Water Research 282 (2025) 123603
X. Li et al. Water Research 286 (2025) 124188

Supports AI-Driven Surveillance

- Generates genomic and metagenomic datasets needed for ML
- Enables feature extraction for predictive AMR modeling
- Integrates environmental data with clinical and laboratory streams
- Provides domain expertise for training and validating AI tools

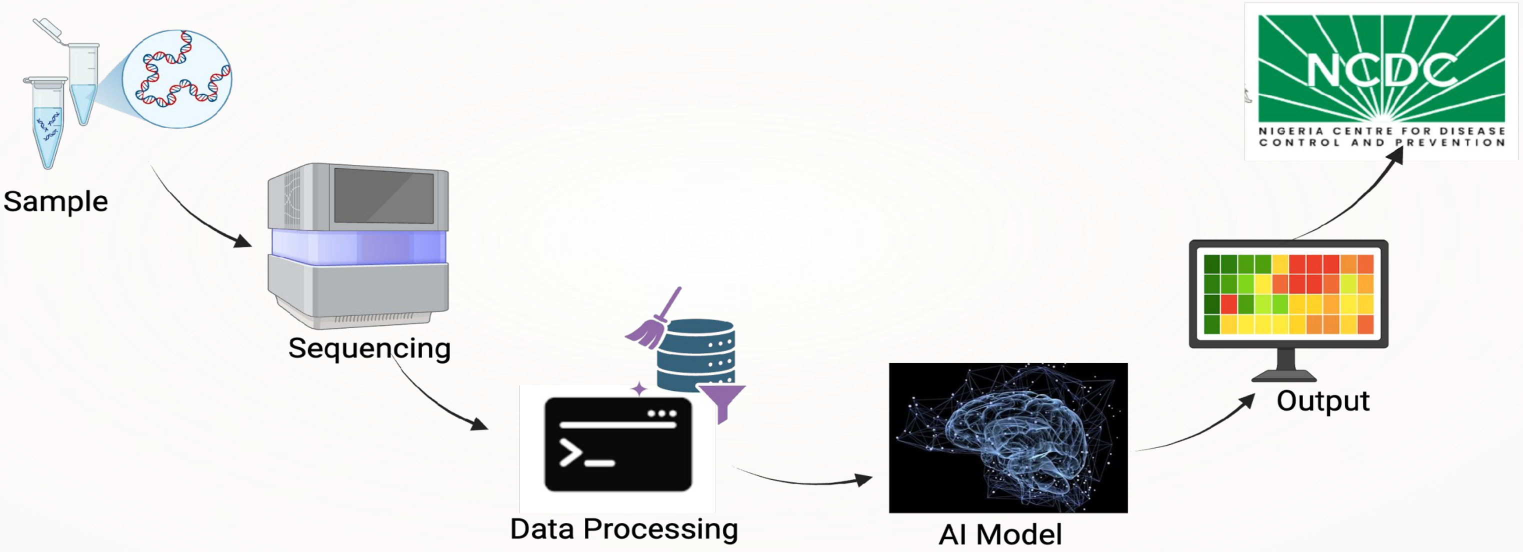
Vision: AI-Enabled AMR Surveillance System for Nigeria

Data Inputs	Integration Layer	AI / Analytics Engine	Outputs for Action
Hospitals	Data harmonization	ML for resistance prediction	Dashboards for NCDC
Clinical labs	Cloud or shared dataset	NLP for clinical notes	Alerts for early warning
Environmental sites	Standardized formats	Hotspot detection	Policy guidance
Wastewater		Trend forecasting	Resource allocation
Built environments			
Genomic labs			

Use Case: Early Warning of Rising Community AMR Signals

- Wastewater and household surface metagenomics detect rising levels of key ARGs
- ML model analyzes temporal patterns to *predict emerging hotspots* in the community
- Signals are cross-checked with available clinical antibiograms to confirm trends
- Alerts are shared with State AMR Technical Working Groups like NCDC AMR Coordination
- NCDC may integrate validated signals into national AMR reports and strengthen GLASS submissions
- Output informs stewardship teams to adjust *community-level* antibiotic guidance early

AI-Enabled Genomic Pipeline for AMR Surveillance in Nigeria



Pilot Roadmap

Act Now: Protect Our Present, Secure Our Future

Pilot data integration selected hospitals and wastewater sites

Adapt ML pipeline using Nigeria’s AMR data

Deploy dashboard and training using AI co-pilot tool

Nigeria can leapfrog by combining environmental, clinical, and genomic surveillance with AI-driven insights.
The tools exist, the opportunity is now.”

Acknowledgments

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NSF PreMiEr

The Global Health Network

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Thank you to the teams and mentors whose support makes this work possible.

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AMR in Nigeria: Current Realities, Challenges, and the Way Forward

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Port Harcourt

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AMR in Nigeria: Current realities, challenges, & the way forward

Dr. Chizaram Onyeaghala

Infectious Diseases Physician

University of Port Harcourt Teaching Hospital, Port Harcourt, Nigeria

WAAW 2025 - 20 November, 2025

Presentation objectives

- To discuss the current situation of AMR in Nigeria

- To discuss the challenges associated with AMR in Nigeria

- To discuss the way forward in addressing AMR in Nigeria

AMR.....*(2)*

- Alexander Fleming, inventor of Penicillin (1881–1955)

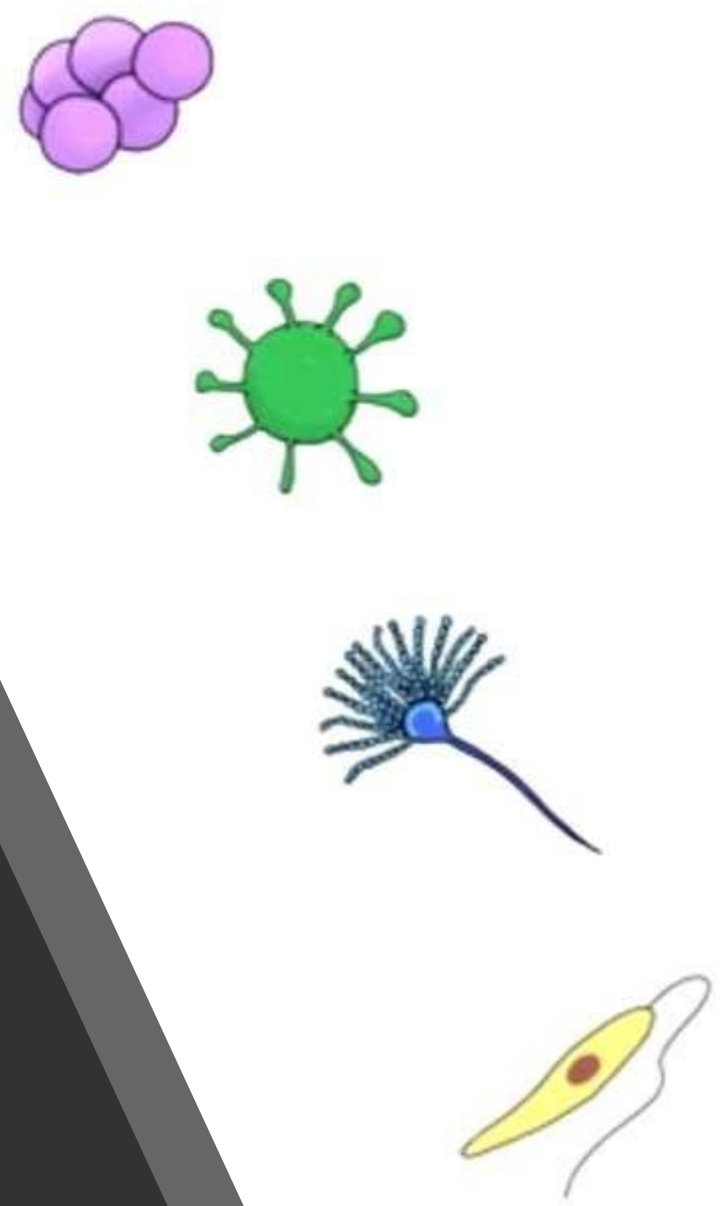
"The time may come when penicillin can be bought by anyone in the shops. Then there is a danger that the ignorant man may easily underdose himself and by exposing his microbes to non-lethal quantities of the drug make them resistant."

*(Alexander Fleming, Nobel Lecture, Dec 11, 1945)**

*

What is AMR?

Antimicrobial Resistance (AMR) occurs when bacteria, viruses, fungi and parasites change over time and no longer respond to medicines making infections harder to treat and increasing the risk of disease spread, severe illness and death.



Antimicrobial Resistance. Fact Sheet. World Health Organisation.

Drug-resistant infections threaten us all — but not equally

Deaths associated with bacterial antimicrobial resistance (AMR), globally and by GBD super-region in 2019.

Number of deaths associated with AMR

256,000 – 1,390,000

Source: The Lancet, Global burden of bacterial antimicrobial resistance in 2019

wellcome

According to a 2022 Lancet study, antimicrobial resistance itself caused

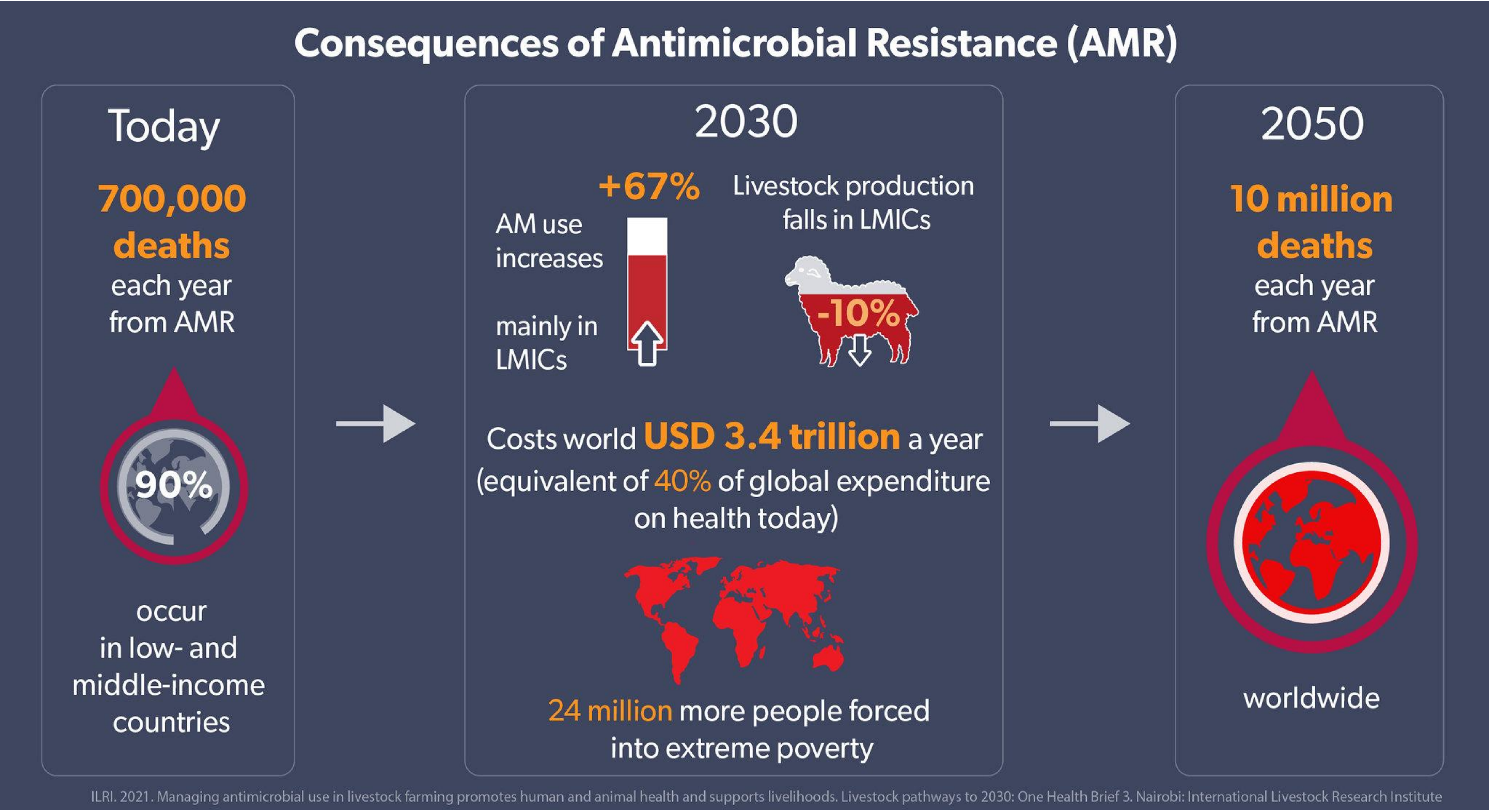
1.27 million

deaths in 2019

and

4.95 million

deaths where antimicrobial resistance played a role.


Consequences of Antimicrobial Resistance (AMR)
Today
700,000 deaths
each year from AMR
90%
occur in low- and middle-income countries
2030
+67%
AM use increases
mainly in LMICs
Livestock production falls in LMICs
-10%
Costs world USD 3.4 trillion a year
(equivalent of 40% of global expenditure on health today)
24 million more people forced into extreme poverty
2050
10 million deaths
each year from AMR
worldwide
ILRI. 2021. Managing antimicrobial use in livestock farming promotes human and animal health and supports livelihoods. Livestock pathways to 2030: One Health Brief 3. Nairobi: International Livestock Research Institute

April, 2025

ICIR

AMR impact

Antimicrobial Resistance (AMR) is a rising global health threat, putting millions of lives and Nigeria's health system at risk

Global

Direct Deaths	1.27M
Associated Deaths	4.95M

It is projected that there will be **10M** annual deaths globally due to AMR by 2050

Nigeria

Direct Deaths	64,500
Associated Deaths	263,400

Nigeria ranks **19th** out of 204 countries in AMR related deaths

*** Figures are based on a 2019 survey from the Global Research on Antimicrobial Resisitance Project*

Source: WHO, NCDC

@theicir www.icirnigeria.org Infographics by: Joshua Akintayo

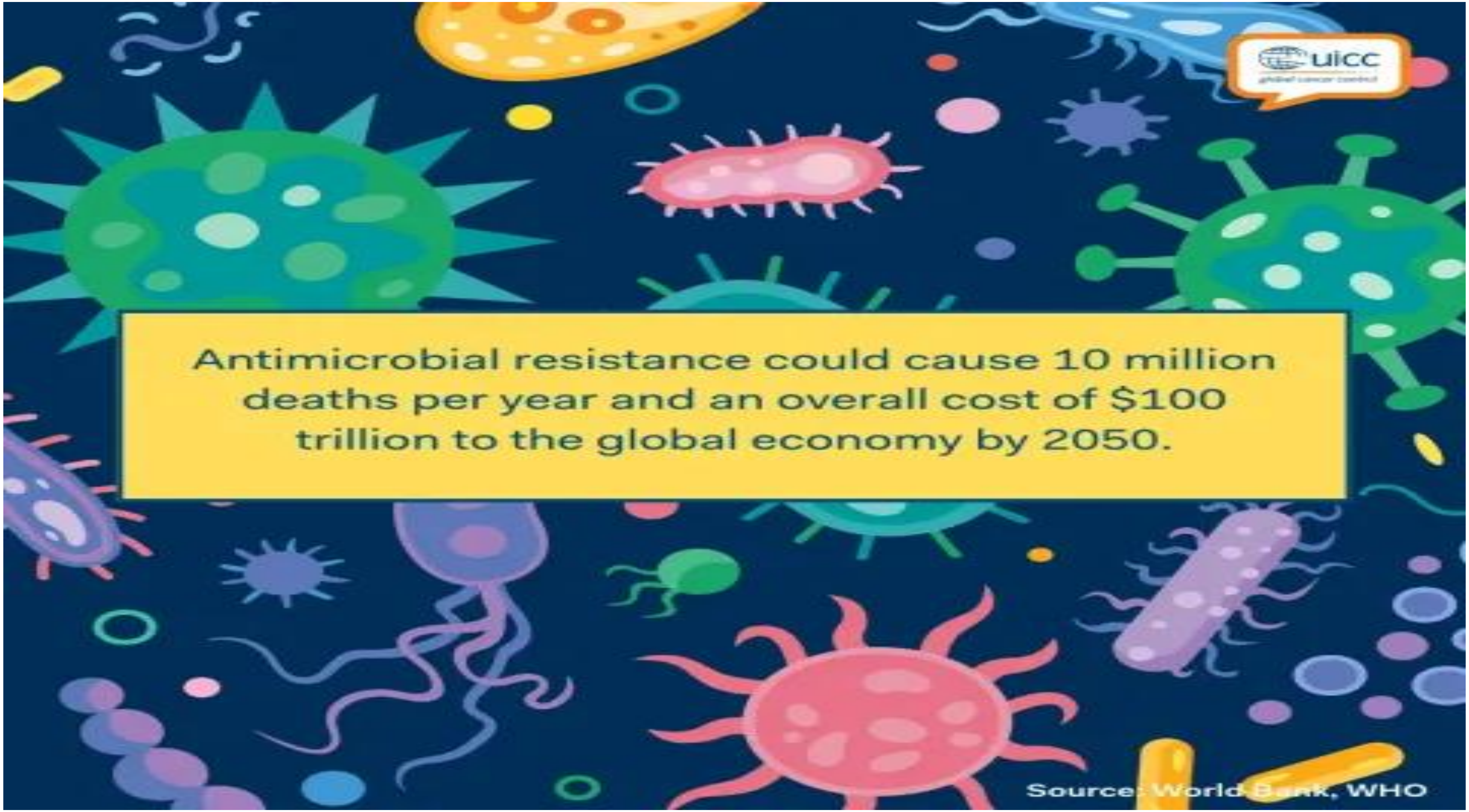
Antimicrobial Resistance (AMR) in Nigeria

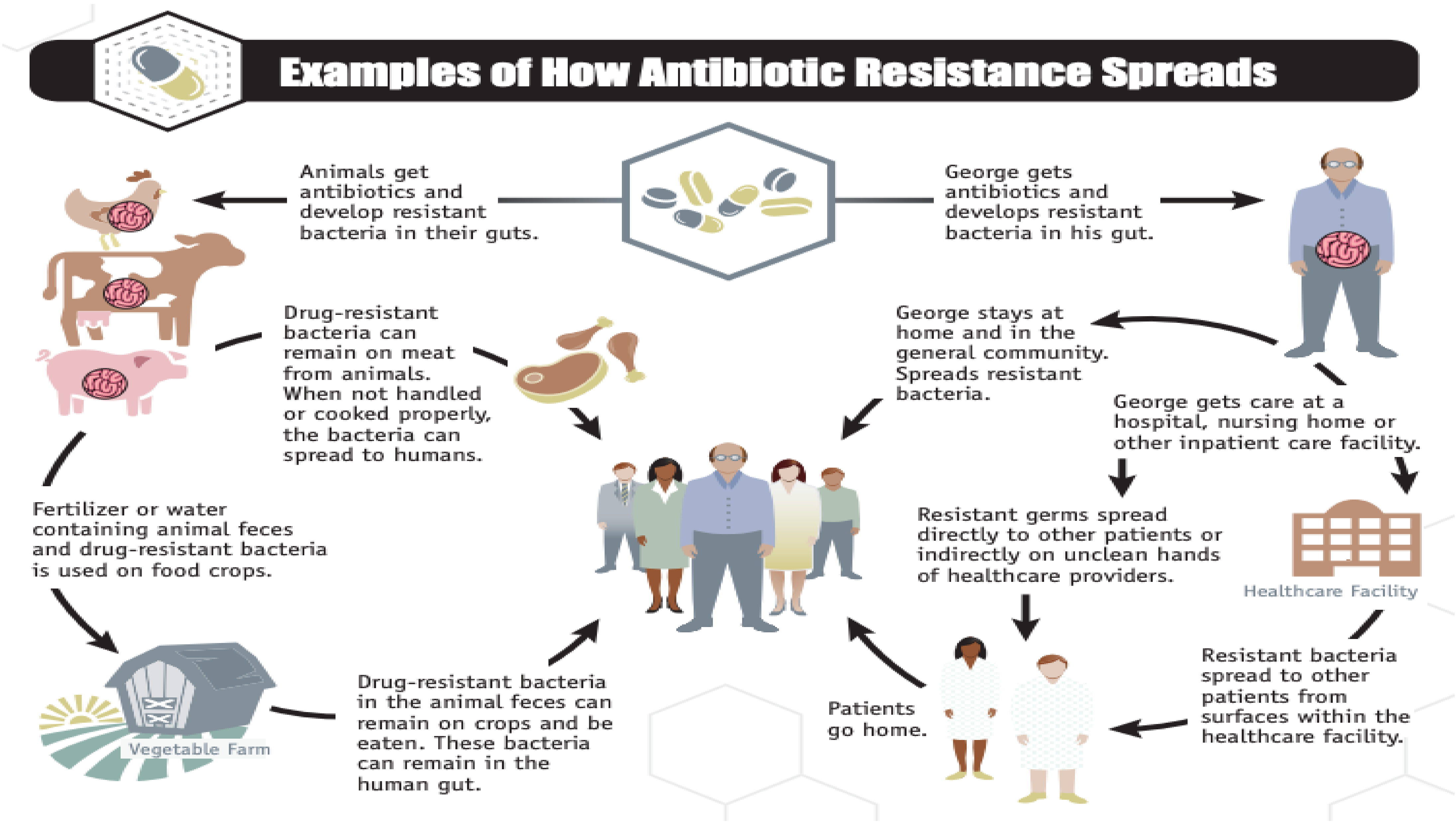
263,400!

Annual AMR-associated deaths

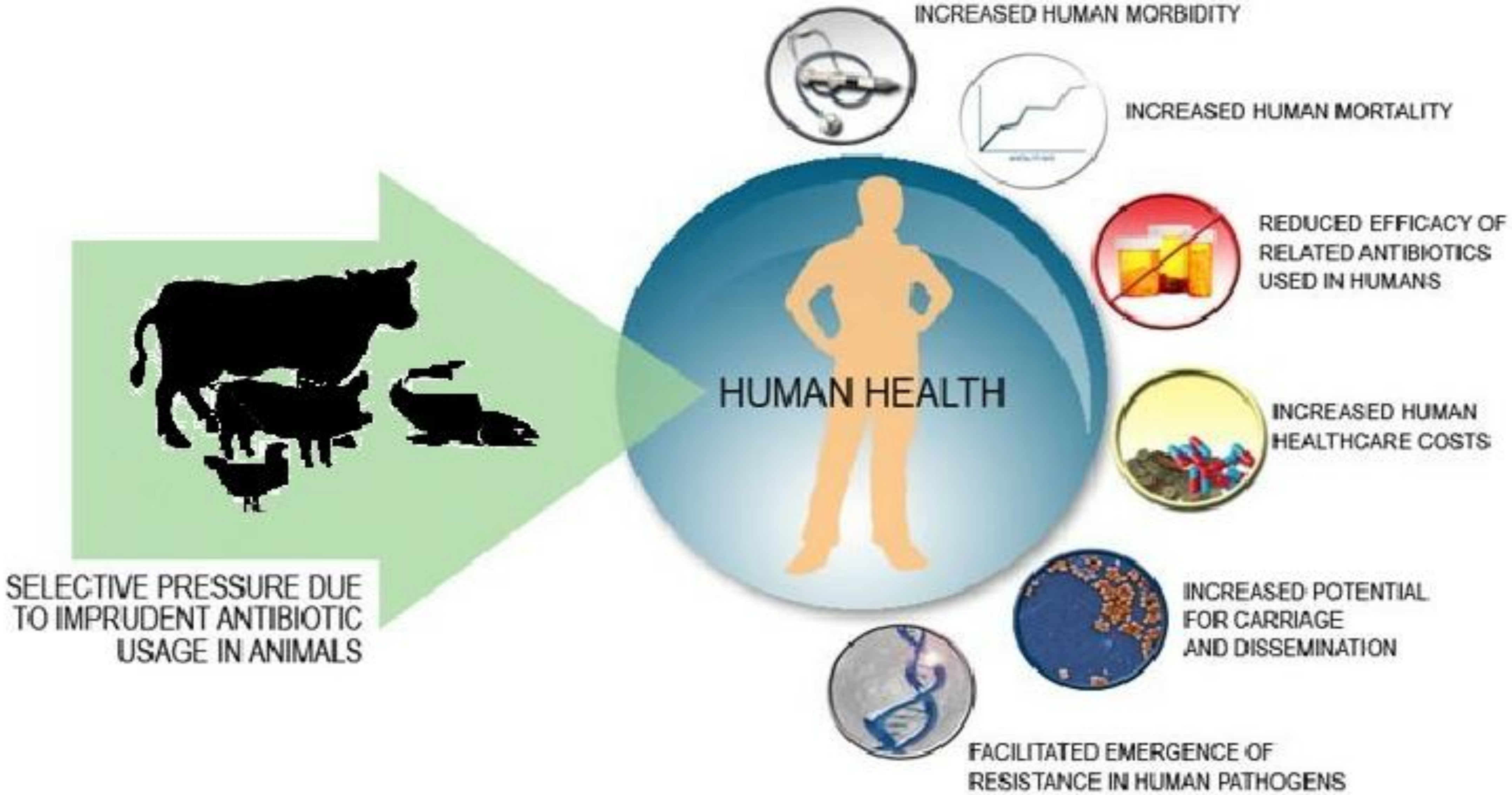
AMR poses a significant public health and economic burden in Nigeria

Source: Nigeria Centre for Disease Control (NCDC)

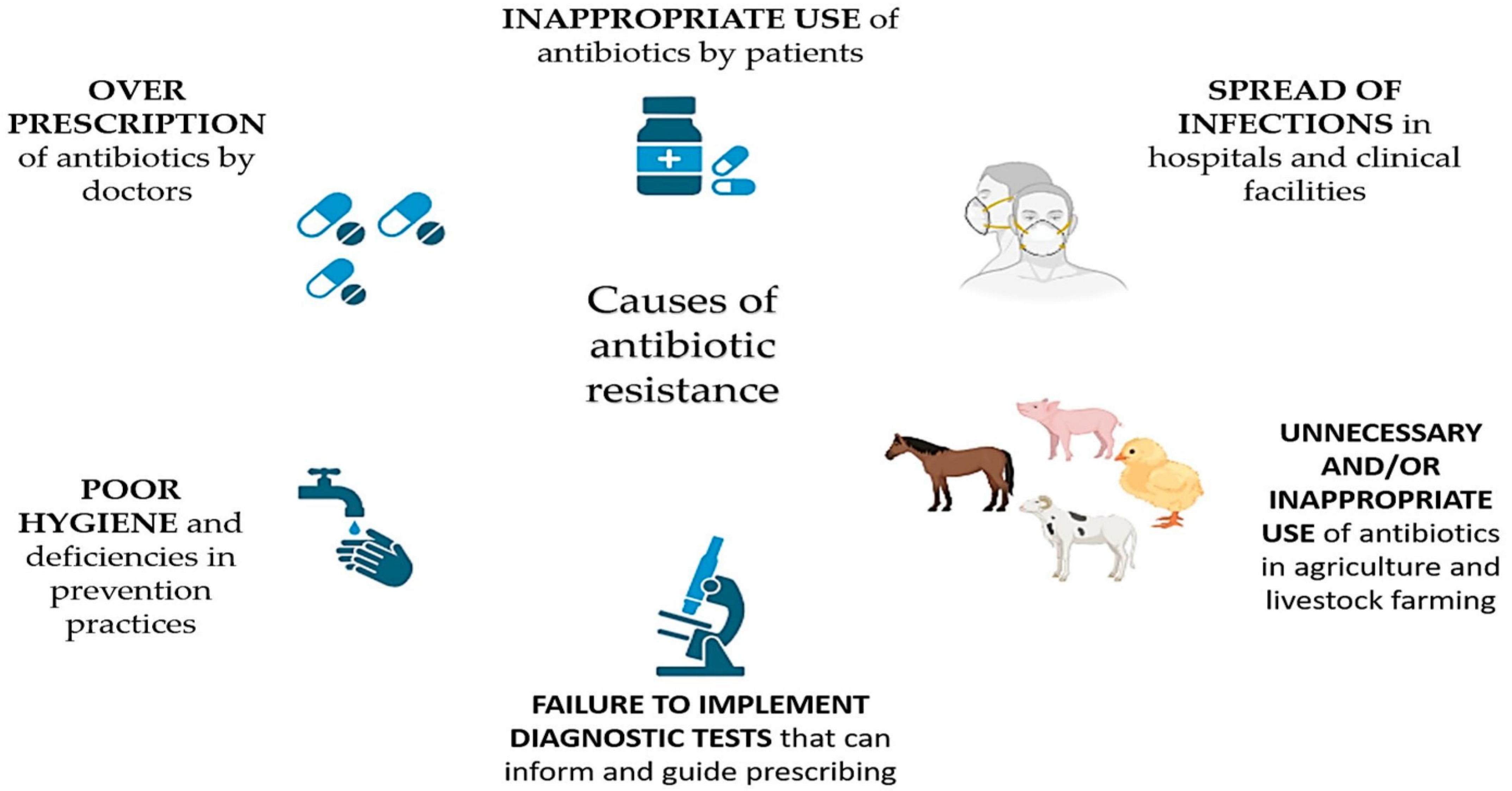

uicc
Antimicrobial resistance could cause 10 million deaths per year and an overall cost of $100 trillion to the global economy by 2050.
Source: World Bank, WHO



Examples of How Antibiotic Resistance Spreads
Animals get antibiotics and develop resistant bacteria in their guts.
George gets antibiotics and develops resistant bacteria in his gut.
Drug-resistant bacteria can remain on meat from animals. When not handled or cooked properly, the bacteria can spread to humans.
George stays at home and in the general community. Spreads resistant bacteria.
George gets care at a hospital, nursing home or other inpatient care facility.
Fertilizer or water containing animal feces and drug-resistant bacteria is used on food crops.
Resistant germs spread directly to other patients or indirectly on unclean hands of healthcare providers.
Healthcare Facility
Vegetable Farm
Drug-resistant bacteria in the animal feces can remain on crops and be eaten. These bacteria can remain in the human gut.
Patients go home.
Resistant bacteria spread to other patients from surfaces within the healthcare facility.

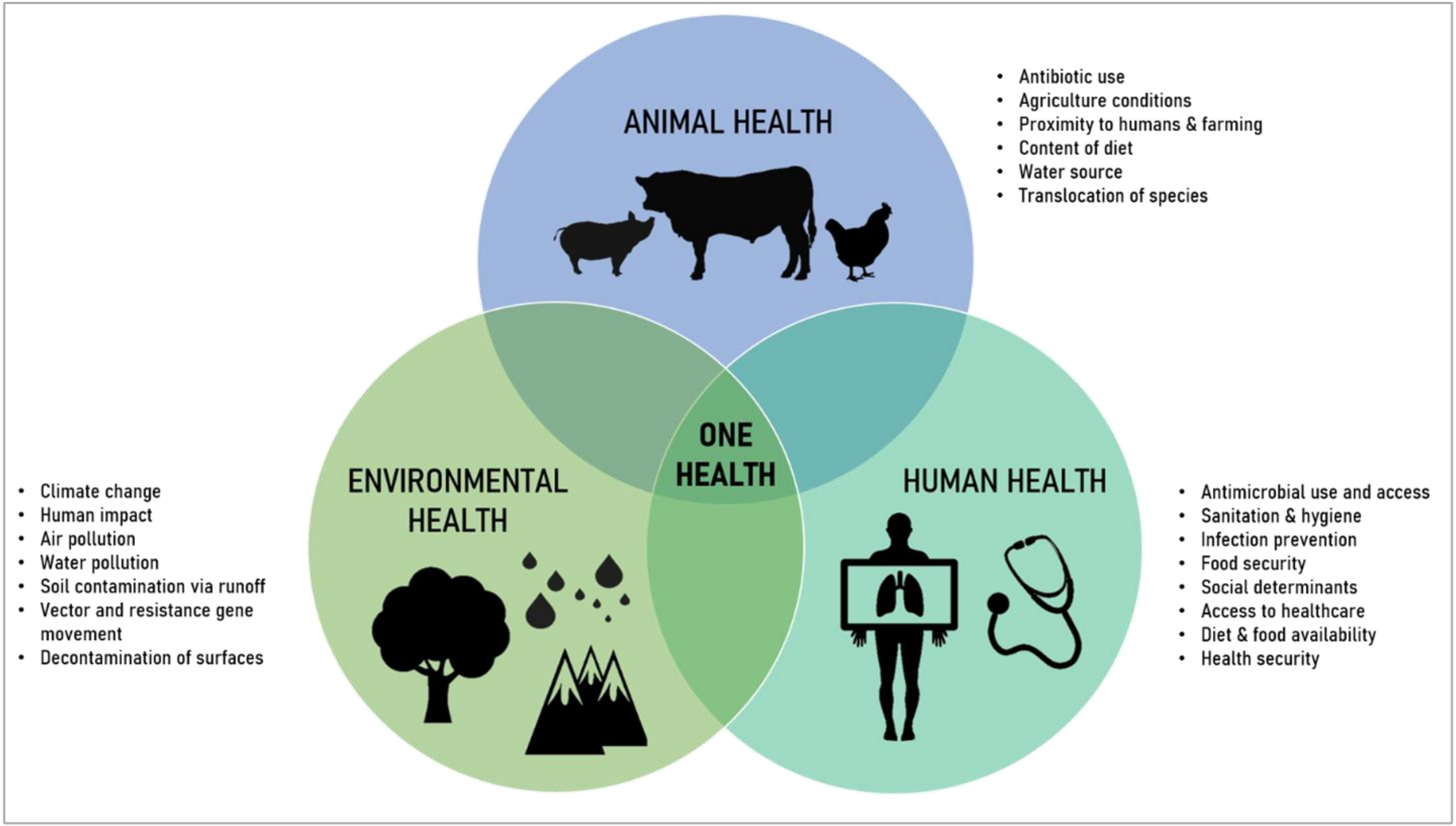


SELECTIVE PRESSURE DUE TO IMPRUDENT ANTIBIOTIC USAGE IN ANIMALS
HUMAN HEALTH
INCREASED HUMAN MORBIDITY
INCREASED HUMAN MORTALITY
REDUCED EFFICACY OF RELATED ANTIBIOTICS USED IN HUMANS
INCREASED HUMAN HEALTHCARE COSTS
INCREASED POTENTIAL FOR CARRIAGE AND DISSEMINATION
FACILITATED EMERGENCE OF RESISTANCE IN HUMAN PATHOGENS


INAPPROPRIATE USE of antibiotics by patients
OVER PRESCRIPTION of antibiotics by doctors
SPREAD OF INFECTIONS in hospitals and clinical facilities
Causes of antibiotic resistance
POOR HYGIENE and deficiencies in prevention practices
UNNECESSARY AND/OR INAPPROPRIATE USE of antibiotics in agriculture and livestock farming
FAILURE TO IMPLEMENT DIAGNOSTIC TESTS that can inform and guide prescribing

Factors behind the acceleration of AMR in Nigeria

- Huge burden of infectious diseases
- Poor sanitation, poor implementation of infection control practices
- Close animal-human interface
- Lack of diagnostics
- Absence/non-adherence to standard treatment guidelines
- Irrational self-administration or prescription
- Drugs available without a prescription
- Poor quality of drugs

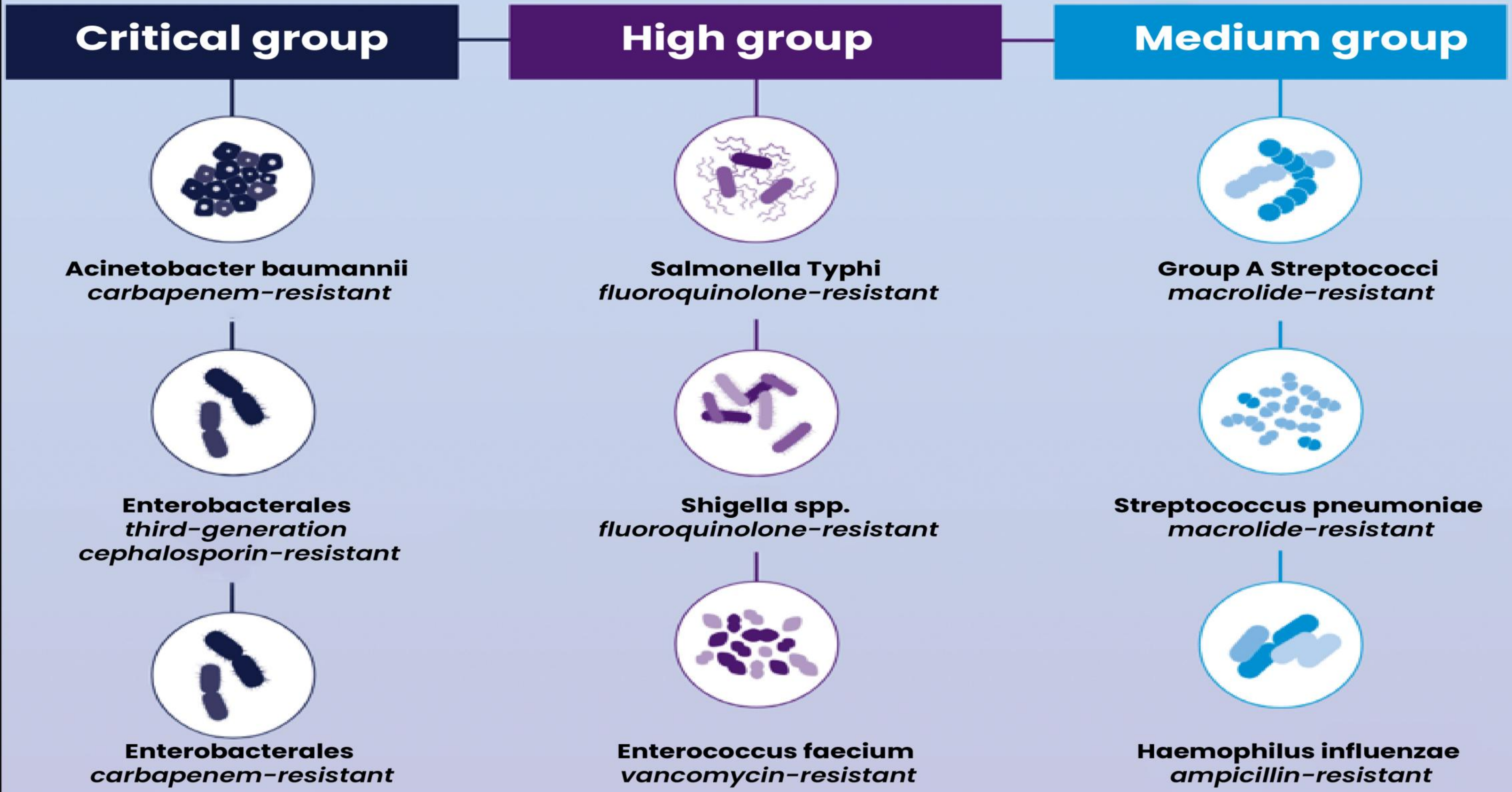

ANIMAL HEALTH
Antibiotic use
Agriculture conditions
Proximity to humans & farming
Content of diet
Water source
Translocation of species
ONE HEALTH
ENVIRONMENTAL HEALTH
Climate change
Human impact
Air pollution
Water pollution
Soil contamination via runoff
Vector and resistance gene movement
Decontamination of surfaces
HUMAN HEALTH
Antimicrobial use and access
Sanitation & hygiene
Infection prevention
Food security
Social determinants
Access to healthcare
Diet & food availability
Health security

Detection of AMR

Phenotypic methods	Genotypic methods
Relates only to the concentration of an antimicrobial that inhibits bacterial growth in vitro.	Provides the opportunity for accelerated cultures, and may even be performed directly on the clinical specimens.
They provide no indication of the mechanisms of resistance which may disseminate to other bacterial species.	These methods help assess the genetic makeup, identify antimicrobial resistance genes and understand the mechanism of resistance.
Time taken – 36-72 hours	Time taken – 30 minutes - 8 hours
For eg. broth microdilution, disk diffusion, gradient tests, agar dilution and breakpoint tests etc.	For eg. Whole Genome Sequencing (WGS), Nucleic acid amplification test, Polymerase Chain Reaction (PCR), Fluorescent in-situ hybridisation (FISH) etc.

Vasala A, Hytönen VP, Laitinen OH. Modern tools for rapid diagnostics of antimicrobial resistance. Frontiers in Cellular and Infection Microbiology. 2020 Jul 15;10:308.

Fig. 1. WHO Bacterial Priority Pathogens List, 2024 update



Global Action Plan on Antimicrobial Resistance

In May 2015, the World Health Assembly adopted a global action plan on antimicrobial resistance, which outlines five objectives:

1. To improve awareness and understanding of antimicrobial resistance through effective communication, education and training
2. To strengthen the knowledge and evidence base through surveillance and research
3. To reduce the incidence of infection through effective sanitation, hygiene and infection prevention measures
4. To optimize the use of antimicrobial medicines in human and animal health
5. To develop the economic case for sustainable investment that takes account of the needs of all countries and to increase investment in new medicines, diagnostic tools, vaccines and other interventions.

NIGERIA HEALTH WATCH

HANDLE ANTIMICROBIALS WITH CARE

Nigeria launched and implemented its first 2017-2022 National Action Plan for Antimicrobial Resistance (NAP). This Strategic Plan aimed to

- Increase awareness and knowledge of AMR and related topics
- Building a One Health AMR Surveillance System
- Intensifying Infection and Prevention Control in tripartite sectors
- Promoting rational access to antibiotics and antimicrobial stewardship
- Investing in AMR Research and Development

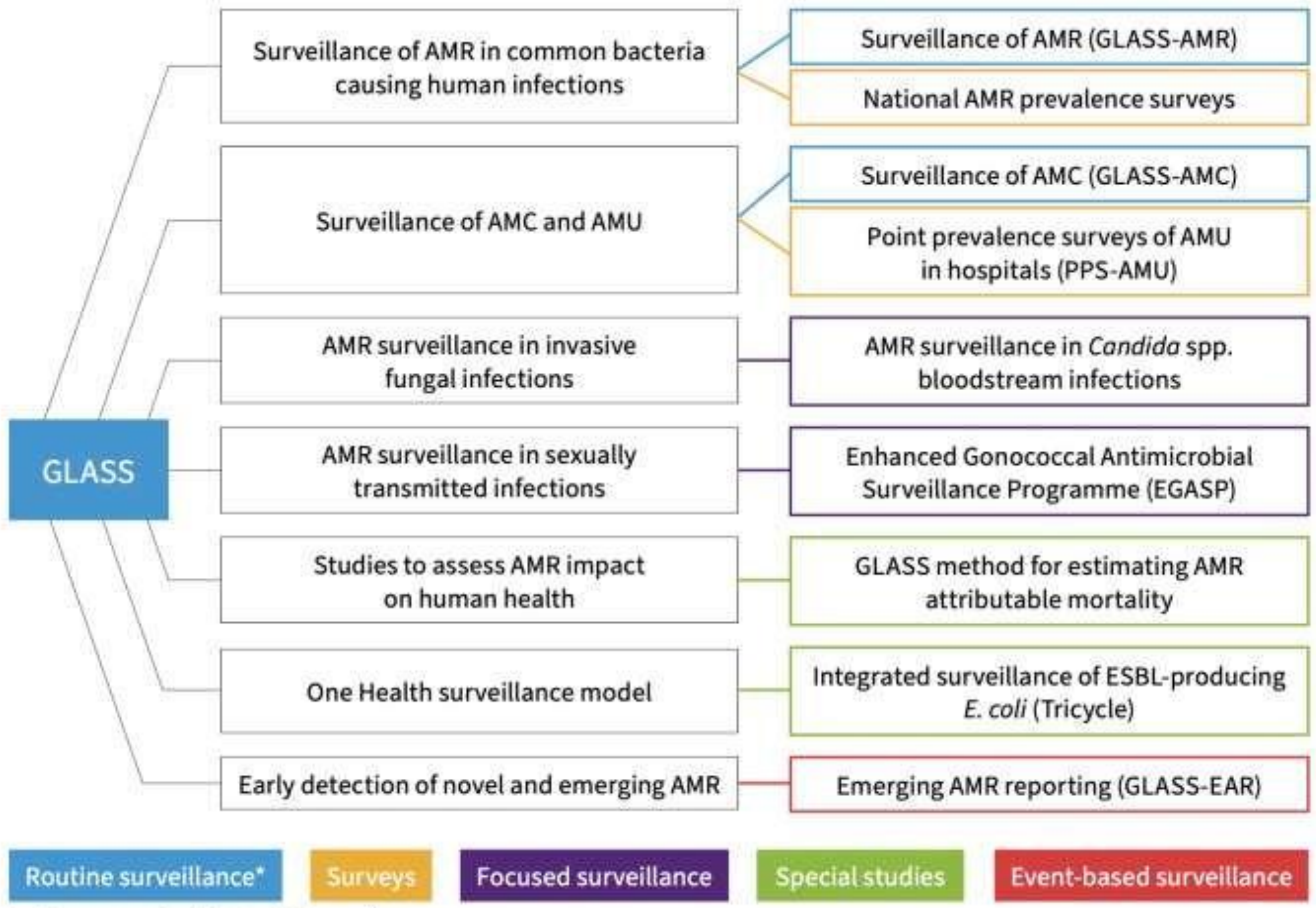
PRIORITY GAPS AS IDENTIFIED IN NIGERIA'S AMR NATIONAL ACTION PLAN 2017–2022.

1. Poor public awareness and weak coordination of AMR awareness activities by government and partners such as vertical disease control programmes.
2. Poor 'One Health' coordination of animal and human national disease surveillance systems, non-existence of a national AMR laboratory surveillance system and no dedicated funding for AMR control activities
3. Non-existence of a national Infection Prevention and Control (IPC) coordinating body or guidelines, and poor budgetary support for IPC activities in health facilities
4. Lack of antimicrobial stewardship in both private and public sectors
5. Studies on the health and economic impact of AMR in Nigeria and poor coordination of research on antibiotic use

Role of Surveillance in AMR

- Cornerstone for assessing the spread of AMR.
- Inform local, national and global strategies.
- Inform infection prevention and control responses.
- Monitor the impact of local, national and global strategies.

Fig. 2.2. GLASS technical modules



* CTAs report national data to WHO annually.

Note: AMR prevalence surveys were not implemented during the first phase of GLASS-AMR. The next phase will involve adopting this complementary approach to address knowledge gaps on the magnitude, distribution and diversity of AMR in LMICs.

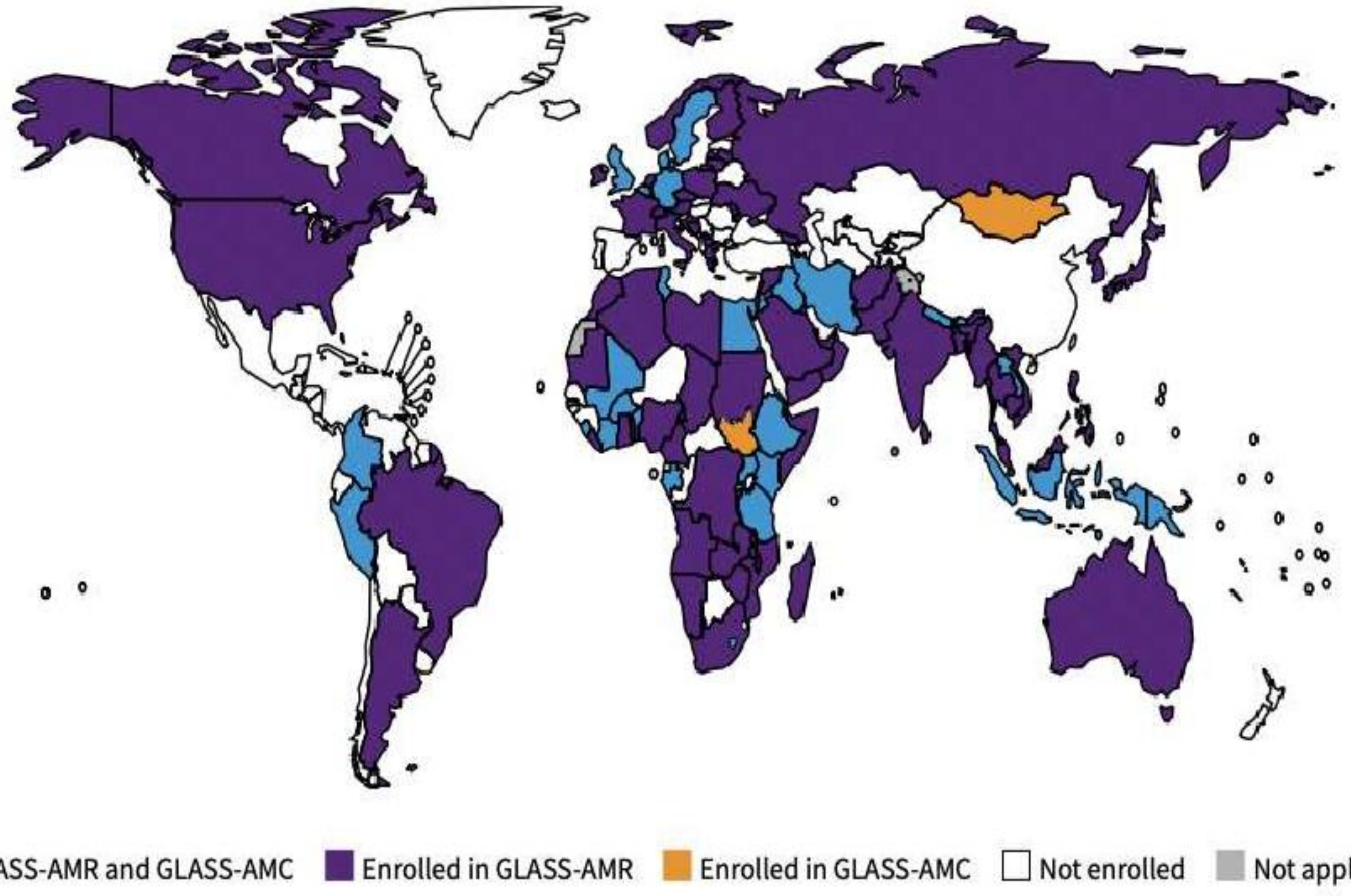
WHO. Initiatives. GLASS.

WHO. Initiatives. GLASS

Global Antimicrobial Resistance and Use Surveillance System (GLASS)

- Launched by the World Health Organization (WHO) in 2015 to support the strengthening of the antimicrobial resistance (AMR) evidence base, the Global Antimicrobial Resistance and Use Surveillance System (GLASS) is the first system that enables harmonized global reporting of official national AMR and antimicrobial consumption (AMC) data.

Enrolment status by end of 2021



Global Antimicrobial Resistance and Use Surveillance System (GLASS) Report, 2022

Challenges in AMR Surveillance Network in Nigeria

Not representative of entire country; Reflection of tertiary care settings and not the general community

High antibiotic use in the community and inadequate implementation of measures to curb sale of over-the-counter antimicrobials; Prior antibiotic exposure data difficult to capture

Continued training support for the staff in order to undertake quality antimicrobial susceptibility testing (AST) and surveillance

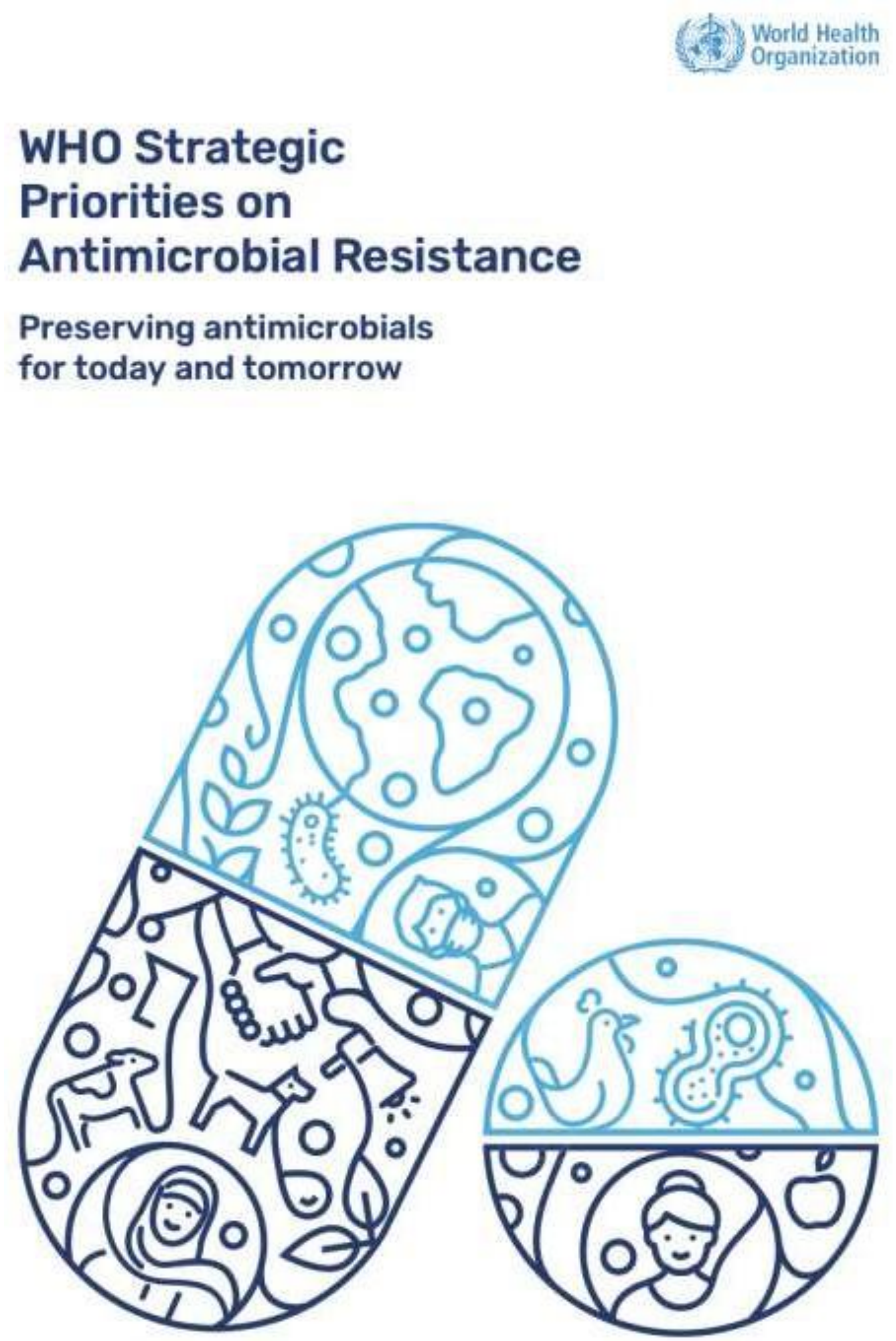
Funding to sustain the quality data over a long period

Limited funding of the AMR R&D Landscape

Physician immunity to changes regarding stewardship policies

Data sharing and private sector involvement

Way forward


World Health Organization
WHO Strategic Priorities on Antimicrobial Resistance
Preserving antimicrobials for today and tomorrow


One Health
ANTIMICROBIAL
RESISTANCE
National Action Plan 2.0
2024–2028


The reviewed action plan outlines six (6) strategic objectives
1
Strengthen leadership, collaboration, coordination, and AMR governance structures at national and subnational levels.
2
Improve antimicrobial resistance (AMR) awareness, education, understanding, and behaviour change among all relevant stakeholders.
3
Improve evidence base through strengthening One Health AMR surveillance systems and operational research for decision making.
4
Improve implementation of infection prevention and control (IPC) programmes, biosecurity, and vaccination uptake including access to WASH across the One Health sectors
5
Improve access to quality antimicrobials and optimise their use across One Health sectors.
6
Build knowledge and capacity of relevant stakeholders to improve local innovations, research and development in antimicrobials, diagnostics, and vaccines.

A Global Journey to Nigeria 2026

Nigeria will host the 5th AMR Ministerial Conference in Abuja (29 – 30 June 2026)

2014 – **1st Ministerial Conference (Netherlands)**
Called for a Global Action Plan on AMR

2015 – WHA adopted the Global Action Plan on AMR

2016 – 1st UNGA High-Level Meeting on AMR

2019 – **2nd Ministerial Conference (Netherlands & Indonesia)**
AMR-MPTF established

2022 – **3rd Ministerial Conference (Oman)**
Muscat Manifesto and AMR Targets

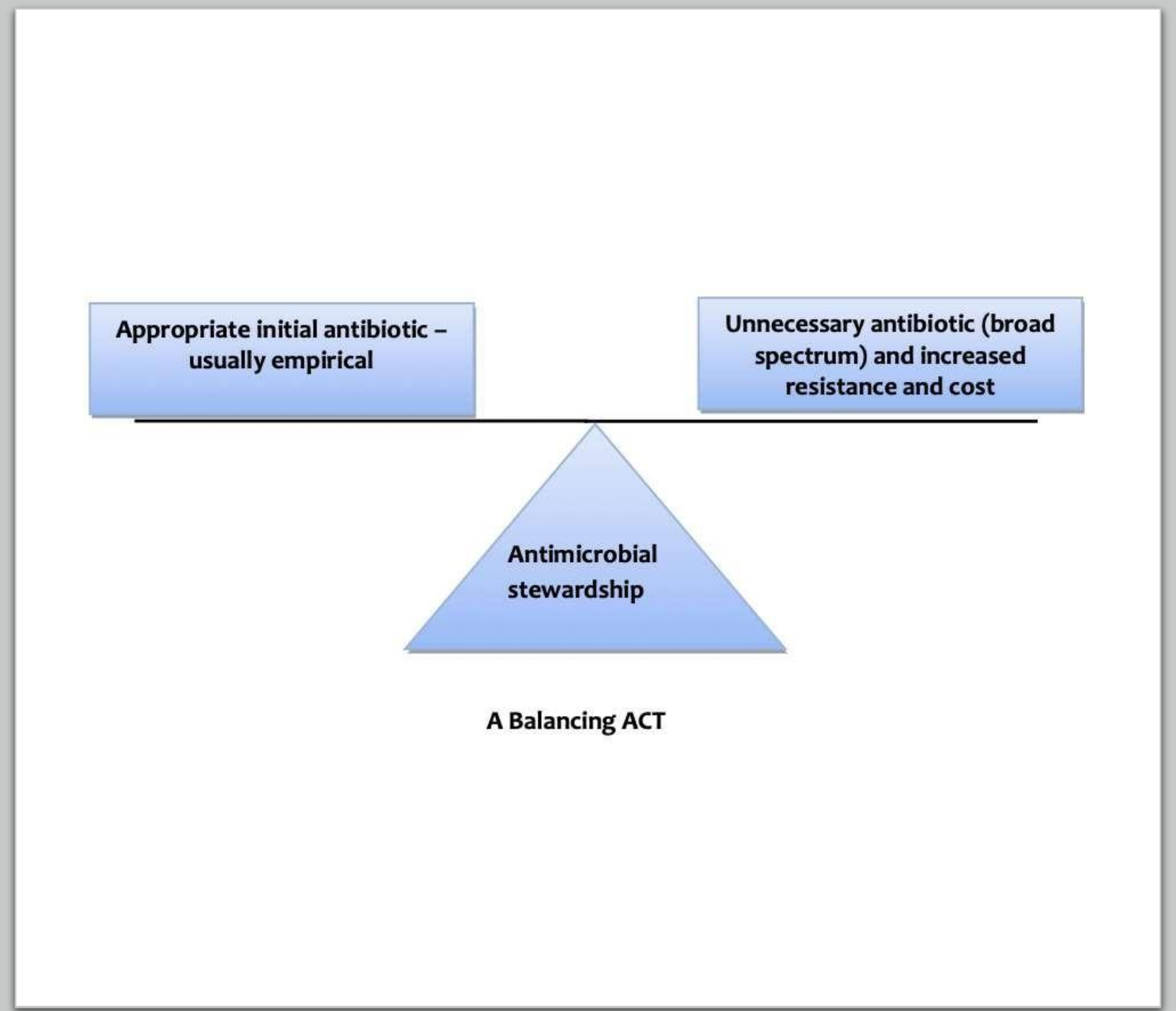
2024 – 2nd UNGA High-Level Meeting on AMR

2024 – **4th Ministerial Meeting on AMR (Saudi Arabia)**
Jeddah Commitments
Learning Hub
Logistics Hub
Biotech Centre

2026 – **5th Ministerial Conference on AMR**
(Nigeria)
Outcome – Abuja Accords

Antimicrobial Stewardship

- Coordinated interventions designed to improve and measure the appropriate use of antimicrobial agents by promoting the selection of the optimal antimicrobial drug regimen, including dosing, duration of therapy, and route of administration.



Components of Antimicrobial Stewardship Program

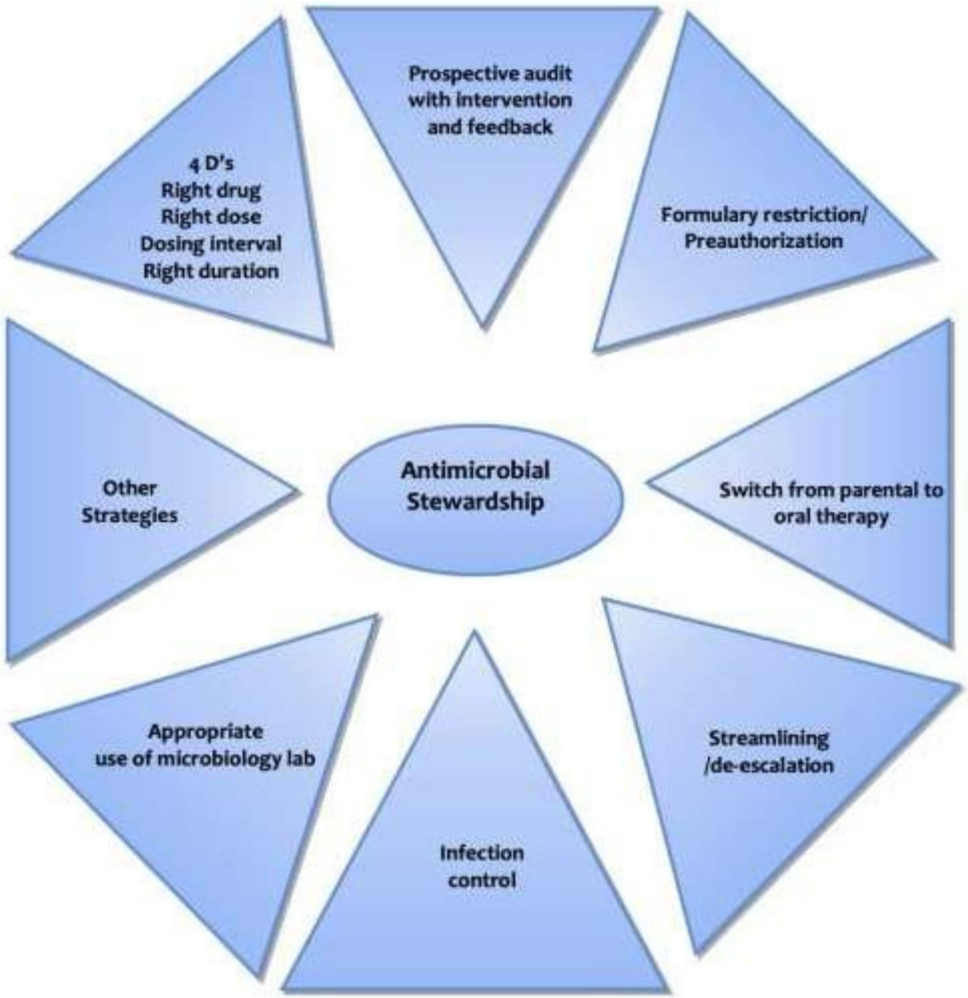


Figure 3. Components of antimicrobial stewardship. However the highest quality of evidence in prospective audit with intervention and feedback and formulary restriction/pre-authorization.

Strategies to improve antimicrobial use

Front-end strategies:

- Antimicrobials are made available through an approval process (formulary restriction and preauthorization)
- Shows immediate reduction in use and expenditure of restricted antibiotics

Back-end strategies:

- Antimicrobials are reviewed after antimicrobial therapy has been initiated (prospective audit and feedback)
- Timely de-escalation of antibiotics
- Reduction in inappropriate use

Principles of Antimicrobial Prescribing. WHO

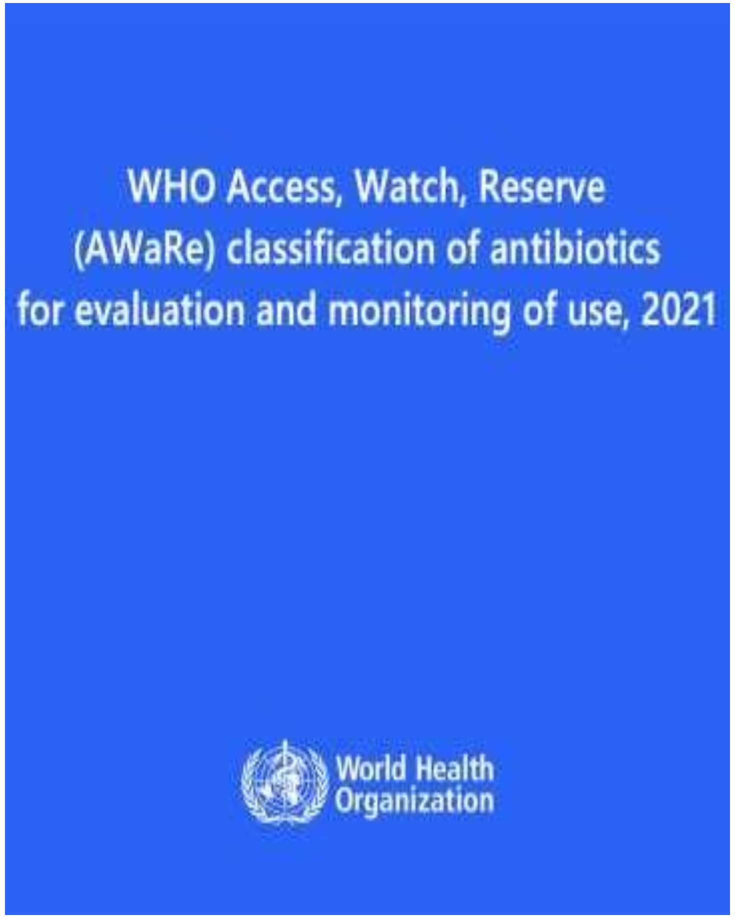
Strategies to improve Antimicrobial Use

	Advantages	Disadvantages
Pre-authorization	• Reduces empiric initiation of inappropriate Antimicrobials • Encourages early and frequent review of culture data • Reduces costs	• May delay therapy • Loss of prescriber autonomy • Impacts only restricted agents
Prospective Audit & Feedback	• Visibility of the stewardship is increased • More data is available, and hence uptake is better. • Educative and collaborative effort, which could address de-escalation and duration of therapy • Prescriber autonomy is maintained	• Labour-intensive • Compliance is voluntary, and prescribers' reluctance to change if the patient is better

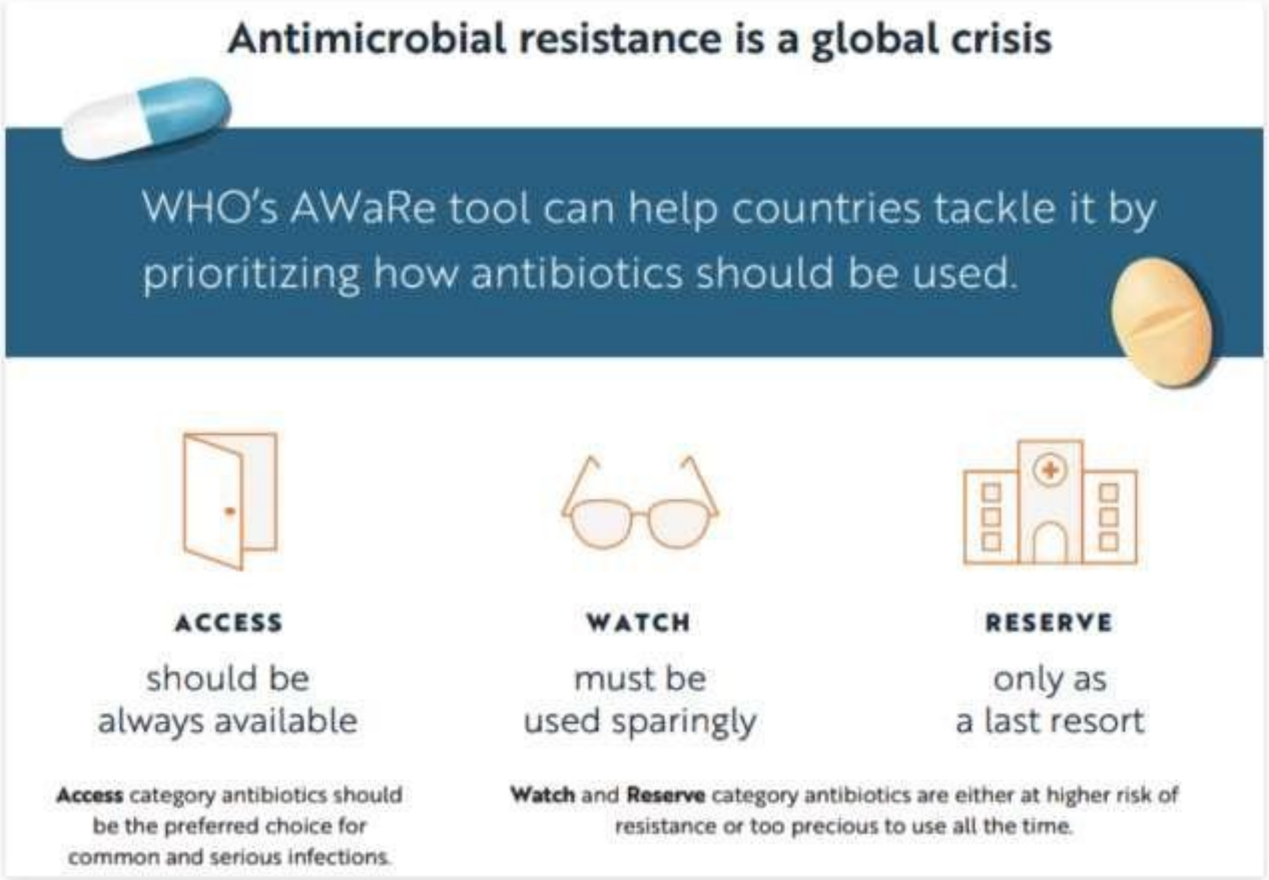
Principles of Antimicrobial Prescribing. WHO

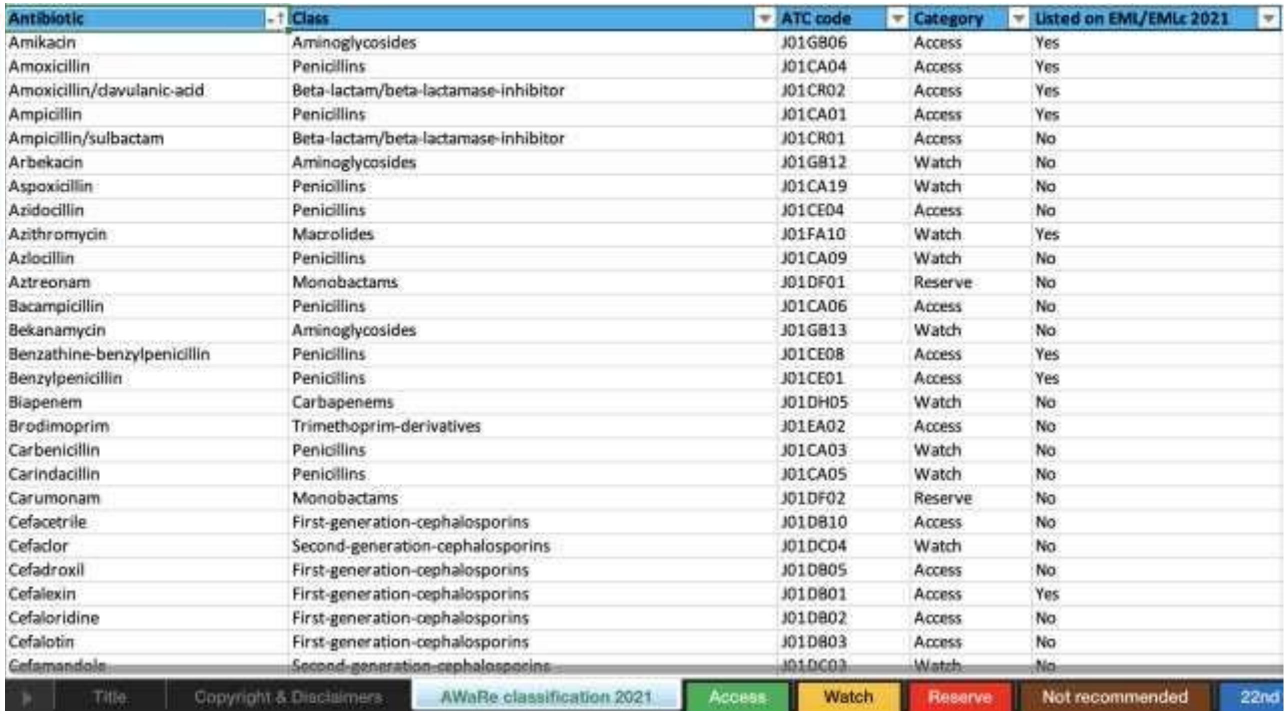
WHO AWaRe Tool

- The AWaRe Classification of antibiotics was developed in 2017 by the WHO Expert Committee on Selection and Use of Essential Medicines as a tool to support antibiotic stewardship efforts at local, national, and global levels.
- Antibiotics are classified into three groups, **Access, Watch, and Reserve,** taking into account the impact of different antibiotics and antibiotic classes on antimicrobial resistance, to emphasize the importance of their appropriate use.
- It is a useful tool for monitoring antibiotic consumption, defining targets, and monitoring the effects of stewardship policies that aim to optimize antibiotic use and curb antimicrobial resistance.



2021 AWaRe Classification. https://www.who.int/publications/i/item/2021-aware-classification

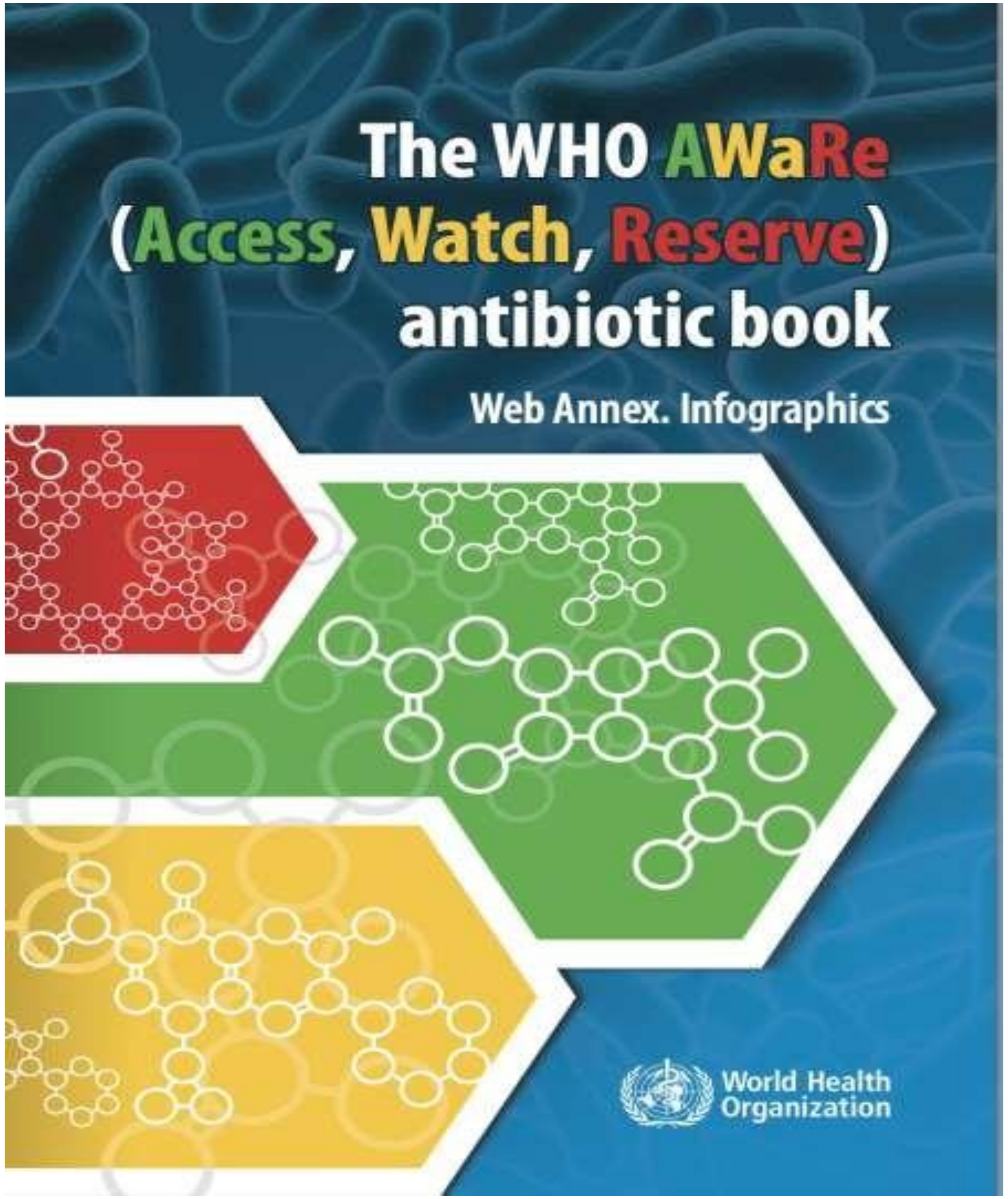




Antibiotic	Class	ATC code	Category	Listed on EML/EMLc 2021
Amikacin	Aminoglycosides	J01GB06	Access	Yes
Amoxicillin	Penicillins	J01CA04	Access	Yes
Amoxicillin/clavulanic-acid	Beta-lactam/beta-lactamase-inhibitor	J01CR02	Access	Yes
Ampicillin	Penicillins	J01CA01	Access	Yes
Ampicillin/sulbactam	Beta-lactam/beta-lactamase-inhibitor	J01CR01	Access	No
Arbekacin	Aminoglycosides	J01GB12	Watch	No
Aspoxicillin	Penicillins	J01CA19	Watch	No
Azidocillin	Penicillins	J01CE04	Access	No
Azithromycin	Macrolides	J01FA10	Watch	Yes
Azlocillin	Penicillins	J01CA09	Watch	No
Aztreonam	Monobactams	J01DF01	Reserve	No
Bacampicillin	Penicillins	J01CA06	Access	No
Bekanamycin	Aminoglycosides	J01GB13	Watch	No
Benzathine-benzylpenicillin	Penicillins	J01CE08	Access	Yes
Benzylpenicillin	Penicillins	J01CE01	Access	Yes
Biapenem	Carbapenems	J01DH05	Watch	No
Brodimoprim	Trimethoprim-derivatives	J01EA02	Access	No
Carbenicillin	Penicillins	J01CA03	Watch	No
Carindacillin	Penicillins	J01CA05	Watch	No
Carumonam	Monobactams	J01DF02	Reserve	No
Cefacetrile	First-generation-cephalosporins	J01DB10	Access	No
Cefaclor	Second-generation-cephalosporins	J01DC04	Watch	No
Cefadroxil	First-generation-cephalosporins	J01DB05	Access	No
Cefalexin	First-generation-cephalosporins	J01DB01	Access	Yes
Cefaloridine	First-generation-cephalosporins	J01DB02	Access	No
Cefalotin	First-generation-cephalosporins	J01DB03	Access	No
Cefamandole	Second-generation-cephalosporins	J01DC03	Watch	No

Title | Copyright & Disclaimers | AWaRe classification 2021 | Access | Watch | Reserve | Not recommended | 22nd

2021 AWaRe Classification Tool



ADULTS

Bronchitis

Definition

A self-limiting inflammation of the trachea and bronchi characterized by persistent cough +/- fever (≥ 38.0 °C) usually caused by a viral infection

Diagnosis

Clinical Presentation

- Acute onset (<2 weeks) of cough lasting > 5 days +/- sputum production and shortness of breath (colour of the sputum does not indicate bacterial infection) +/- fever (≥ 38.0 °C)
- Generally a mild condition; cough usually lasts 10-20 days (can last longer)

Important: Symptoms can overlap with pneumonia and this can lead to inappropriate treatment with antibiotics. This should be avoided with a careful patient assessment
- **Bronchitis**: Less severe presentation, usually self-limiting (but cough may take weeks to resolve)
- **Pneumonia (see "Community-acquired pneumonia" infographic)**: More severe presentation with shortness of breath and systemic signs of infection (e.g. increased heart and respiratory rate)

Microbiology Tests

Usually not needed; consider testing for Influenza virus or SARS-CoV-2 (e.g. during influenza season or outbreaks based on local epidemiological risk/situation/protocols)

Other Laboratory Tests

Usually not needed

Imaging

Usually not needed

Most Likely Pathogens

Respiratory viruses:
- Rhinovirus
- Influenza virus (A and B)
- Parainfluenza virus
- Coronavirus (including SARS-CoV-2)
- Respiratory syncytial virus (RSV)
- Metapneumovirus
- Adenovirus
- Other respiratory viruses

Treatment

No Antibiotic Care

- Symptomatic treatment
- Bronchodilators (in case of wheezing), mucolytic or antitussive agents, can be considered based on local practices and patient preferences

Patients should be informed that:
- Great majority of cases are self-limiting and of viral origin
- Cough can persist for several weeks

Symptomatic Treatment

Medicines are listed in alphabetical order and should be considered equal treatment options

Ibuprofen 200-400 mg q6-8h (Max 2.4 g/day)

OR

Paracetamol (acetaminophen) 500 mg-1 g q4-6h (max 4 g/day)
- **Hepatic impairment/cirrhosis**: Max 2 g/day

Antibiotic Treatment

Antibiotic treatment is **not recommended and should be avoided** as there is no evidence of a significant clinical benefit and there is a risk of side effects of antibiotics

Steps of rational antimicrobial use

- Making a clinical diagnosis
- Limiting empiric antimicrobial therapy
- Know your bugs
- Choose an appropriate antimicrobial medication
- De-escalation/modification
- Identify clinical situations where antimicrobial use needs to be stopped
- Reduce duration of therapy
- Optimize pharmacodynamics and pharmacokinetics

To the Government

To curb AMR effectively, government must continue implementing the proposed actions under the five focus areas identified in the national AMR action plan:

1. Increase awareness and knowledge of AMR and related topics.
2. Build a 'One Health' AMR surveillance system.
3. Intensify infection prevention and control efforts in human health, animal health and the environment at community and all governmental levels, promoting food safety and the use of vaccines in humans and animals.
4. Improve access to quality antimicrobial agents for infections, promote antimicrobial stewardship and strengthen regulatory agencies across all sectors.
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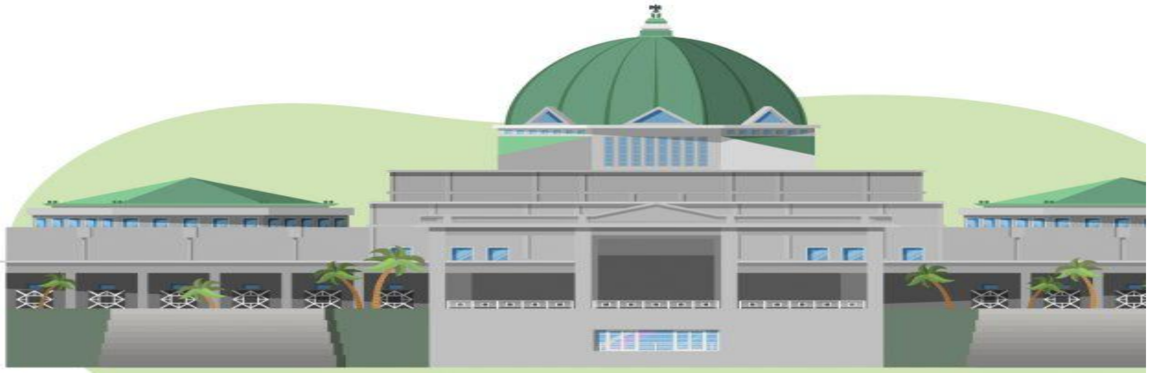


How can we prevent antimicrobial resistance together?

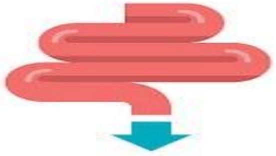
Antimicrobial resistance will affect everybody regardless of where they live, their economic status or lifestyle. It is therefore critical to engage all of society as well as adopt a one health approach to help save millions of lives, preserve antimicrobials for generations and secure the future from drug-resistant pathogens.

To the Public

When preparing food, washing hands before cooking and keeping food preparation areas clean can help prevent the spread of drug resistant microbes.

Human-induced pollution exacerbates AMR in the environment. The treatment of municipal, agricultural, and industrial waste are important preventive measures.

Access to safe water, sanitation and hygiene (WASH) in homes and health facilities can reduce the need for antibiotics to treat diarrhoea by up to 60 percent. WASH helps prevent drug resistant infections, saves lives and reduces health care costs.

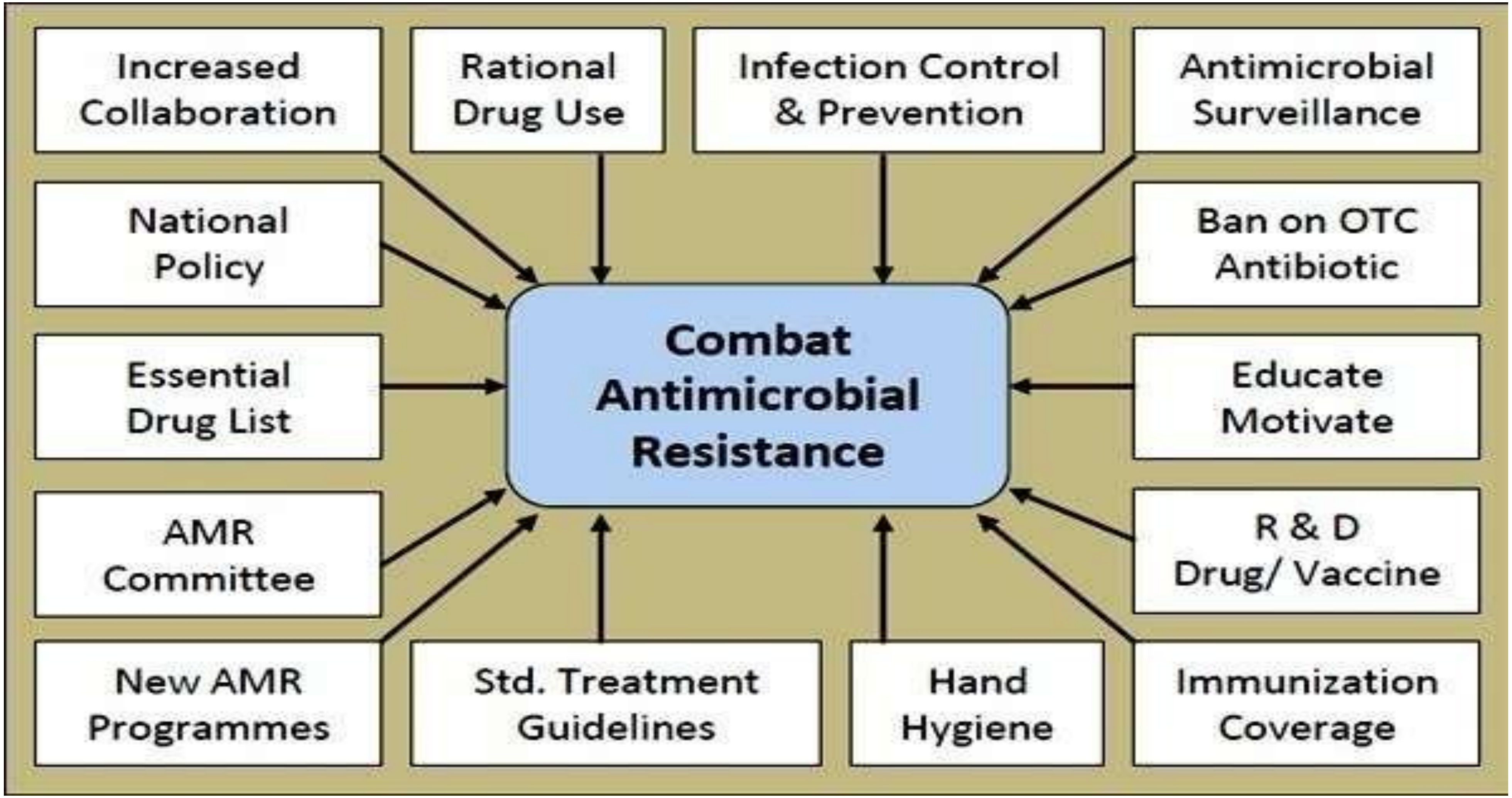


Keep antimicrobial medicines working through correct use. Take them only as directed by a health worker.

Follow directions on treatment dosage and duration, even if you feel better.

Don't share or use leftover antimicrobials.

Mitigation Strategies



Uchil RR, Kohli GS, Katekhaye VM, Swami OC. Strategies to combat antimicrobial resistance. J Clin Diagn Res. 2014 Jul;8(7):ME01-4.

HANDLE

ANTIMICROBIALS

WITH CARE


COMBAT
DRUG
RESISTANCE
NO COMMITMENT
WEAK SURVEILLANCE
LACK OF RESEARCH
DRUG
RESISTANCE
NO INFECTION CONTROL
POOR DRUG QUALITY
IRRATIONAL DRUG USE
No action today,
no cure tomorrow
World Health
Organization

THANK YOU