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AMR
Antimicrobial Resistance Knowledge Hub

THE GLOBAL HEALTH NETWORK
MIDDLE EAST AND NORTH AFRICA

World Antimicrobial Awareness Week (WAAW) 2025 Webinar Series

One Health in Action: MENA strategies to tackle AMR across human, animal, and environmental health

When: **21st November 2025**

Time: **10:00 GMT**

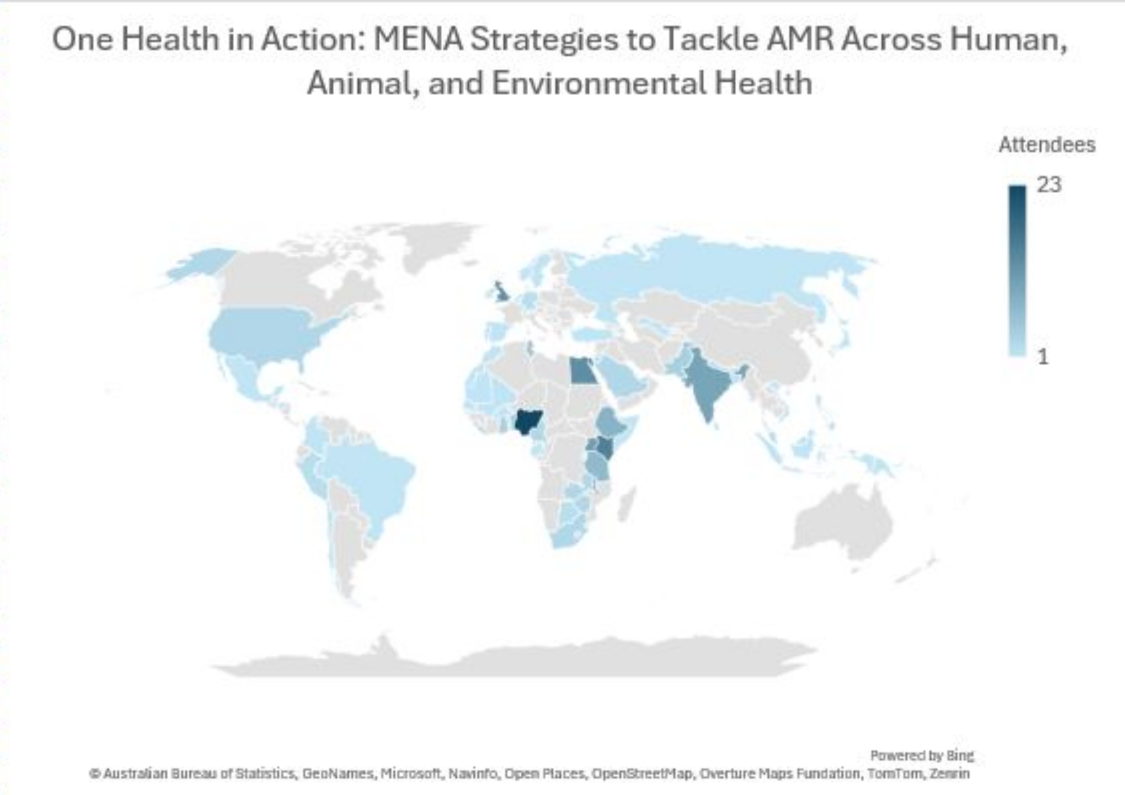
WORLD AMR AWARENESS WEEK
18-24 NOVEMBER

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	23
Palestine	21
Kenya	15
Egypt	13
UK	13
Uganda	11
India	10
Malawi	10
Ethiopia	8
Tanzania	7
Tunisia	6
Benin	5
Ghana	4
Pakistan	4
Cameroon	3
DRC	3
Lebanon	3
Liberia	3
Saudi Arabia	3
South Africa	3



Panel & Agenda

Chair: Godwin Pius Ohemu - Graduate Assistant, AMR Knowledge Hub and CoP, The Global Health Network, University of Oxford, UK

Welcome/Opening Remark: Dr. Mohammed Alkhaldi - Scientific lead and regional coordinator, The Global Health Network, MENA

Empowering One Health Systems through Genomics: Regional Strategies for Antimicrobial Resistance Control - **Dr. Mohamed Elhadidy**, Professor of Biomedical Sciences, Director of Center for Genomics (CG) and Vice Director of Teaching Effectiveness Office (TEO), Zewail City of Science and Technology, Egypt.

Antimicrobial Resistance from the One Health Lense - **Dr. Heba Mahrous**, One Health Technical Officer, WHO Regional Office for the Eastern Mediterranean (EMRO)

Antimicrobial Resistance Support to Countries - **Dr. Shaffi Fazaludeen Koya**, Medical Officer, AMR/IPC/One Health Unit, Department of Health Promotion, Disease Prevention & Control, WHO Regional Office for the Eastern Mediterranean

One Health Approach to Antimicrobial Resistance in Fragile Health Systems: The Case of Palestine - **Dr. Said F. Abukhattab**, Scientific Researcher, Institute of Community and Public Health, Birzeit University, Birzeit University (Palestine).

Q&A - Dr. Mohamed Elhadidy, Dr. Heba Mahrous, Dr. Shaffi Fazaludeen Koya, and Dr. Said F. Abukhattab

Closing Remark - **Maryam Wakkaf** - Technical working group member, The Global Health Network, MENA

Scribe - **Nana Osei Bonsu**, AfOx Ubuntu Fellow

Empowering One Health Systems through Genomics: Regional Strategies for Antimicrobial Resistance Control

Dr. Mohamed Elhadidy

Professor of Biomedical Sciences, Director of Center for Genomics (CG) and Vice Director of Teaching Effectiveness Office (TEO), Zewail City of Science and Technology, Egypt.

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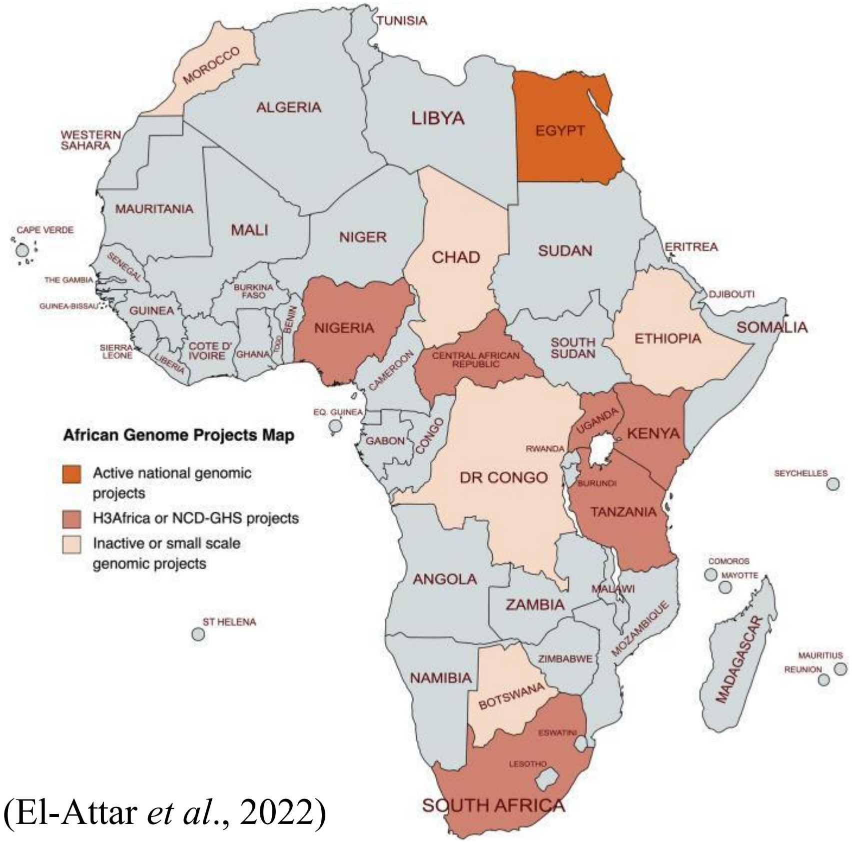
Empowering One Health Systems through Genomics: Regional Strategies for Antimicrobial Resistance Control

Mohamed Elhadidy
Professor of Biomedical Sciences
Director of Center for Genomics (CG)
Zewail City of Science and Technology
Egypt

About the Centre for Genomics: Our Vision

CG aims to lead National initiatives in cutting-edge basic and translational research, training, and science outreach activities in the field of microbial genomics, and to foster the competency of Egyptian researchers in that field

Bridging the genomic data gap in Africa



(El-Attar *et al.*, 2022)

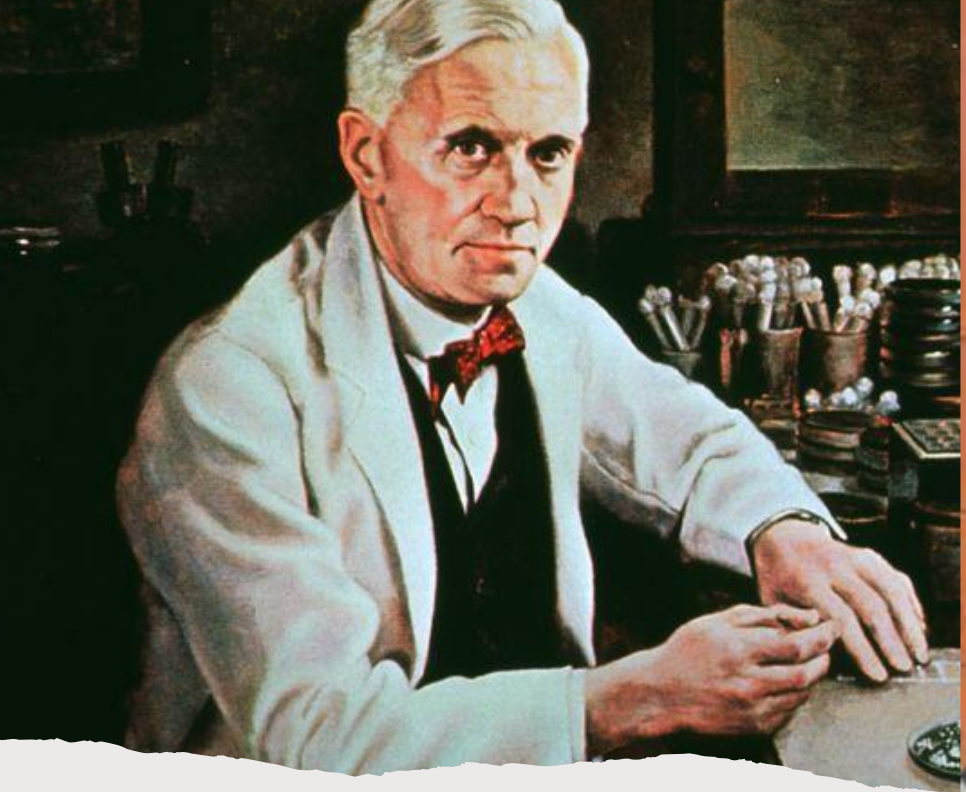
EGYPT GENOME
EGYPTIAN GENOME PROJECT

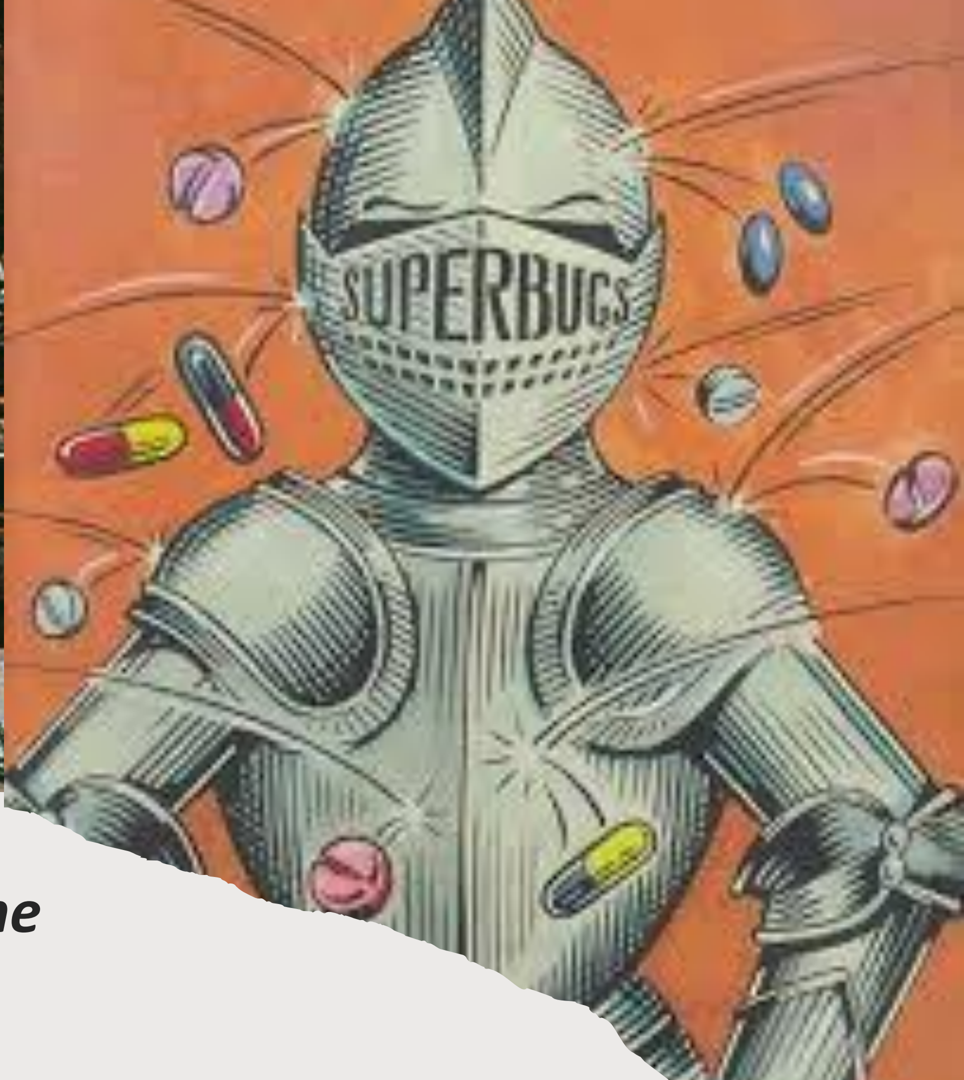
African BioGenome Project
Genomics for the future of biological diversity across Africa

AfricaCDC
Centres for Disease Control and Prevention

SeqAfrica

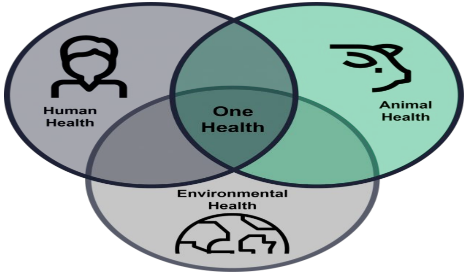
H3Africa
Human Heredity & Health in Africa





Superbugs: While searching for the hero, we created the monster!!

Shared challenges require shared solutions

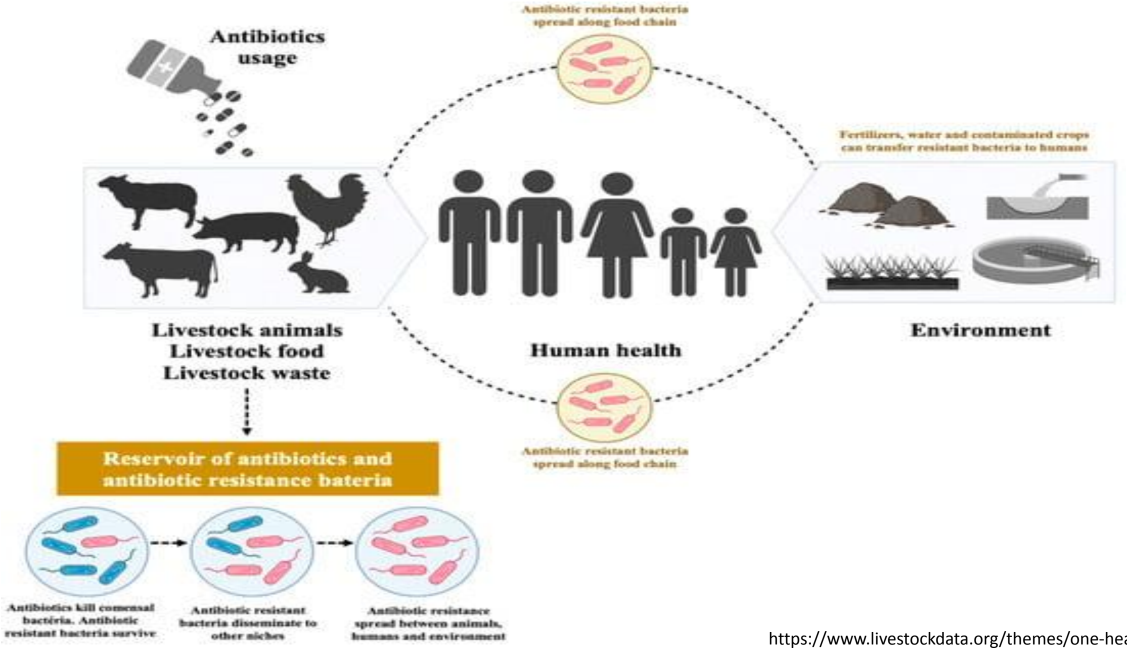


One Health beyond Zoonoses

Priority areas

- Emerging pathogens
- Pandemics
- Endemics and NTDs
- Sanitation
- AMR
- NCDs, Mental health
- Diet, nutrition and Health
- Occupations health
- Food safety and security

And more….



https://www.livestockdata.org/themes/one-health

Rethinking Resistance: Strategies to Combat AMR

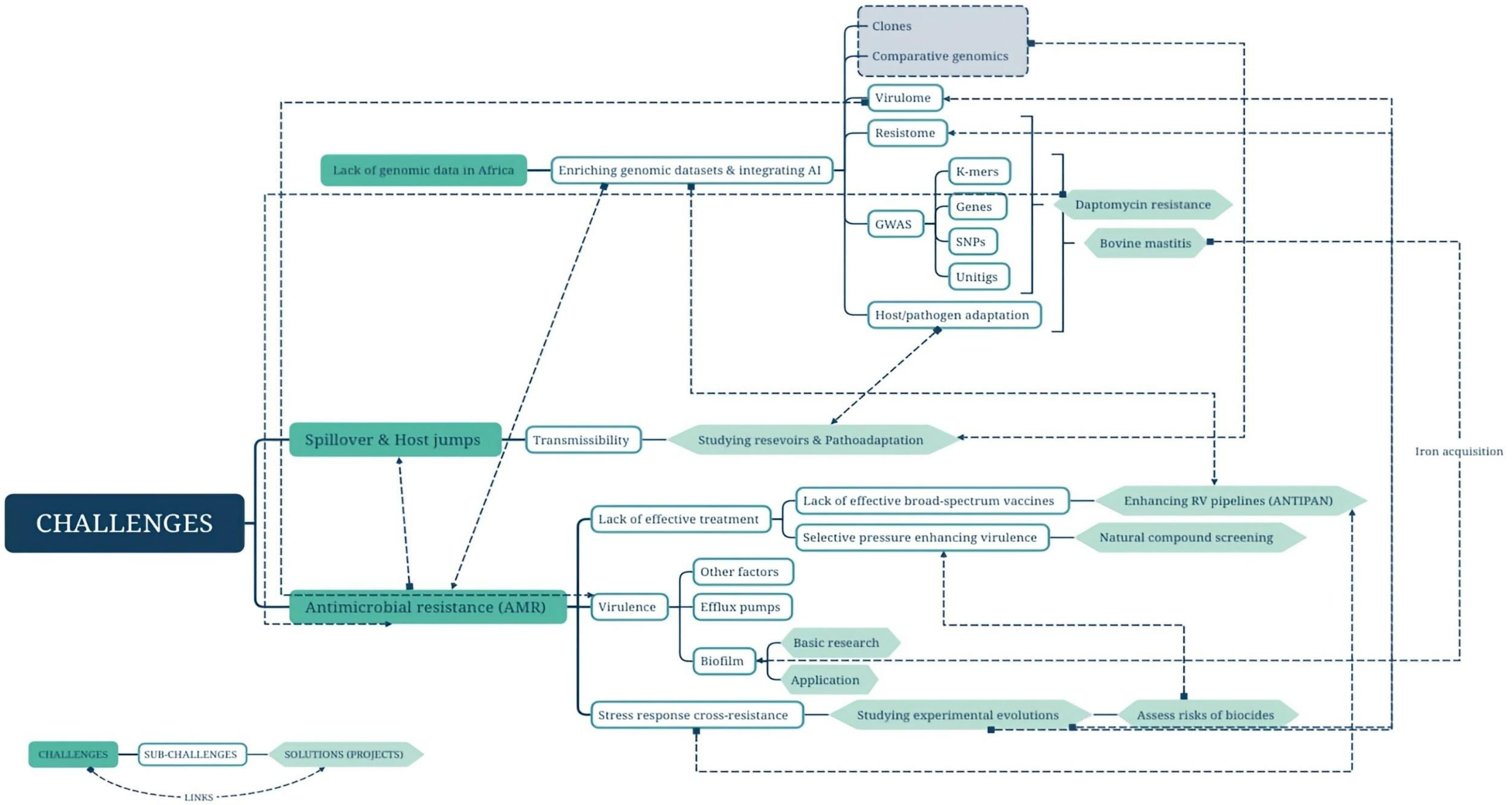
- MORE ANTIBIOTICS: CUPBOARD MAY BE BARE?
- PHAGE THERAPY
- ANTIVIRULENCE THERAPIES
- GENOMIC SURVEILLANCE
- VACCINES
- A COMBINATION OF APPROACHES WILL BE REQUIRED

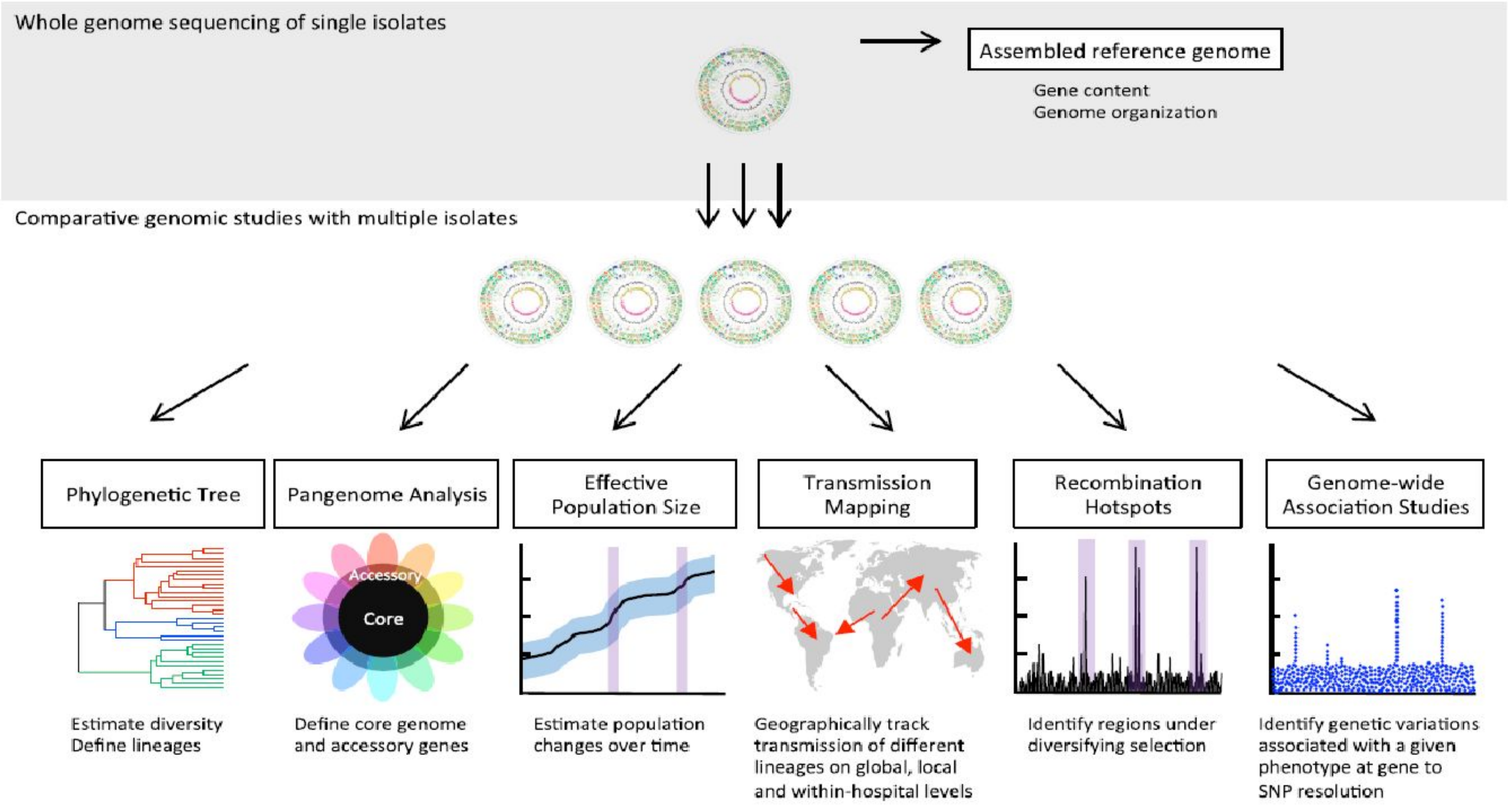
Center for Genomics

CG FRAMEWORK

THROUGH THE ONE HEALTH LENS

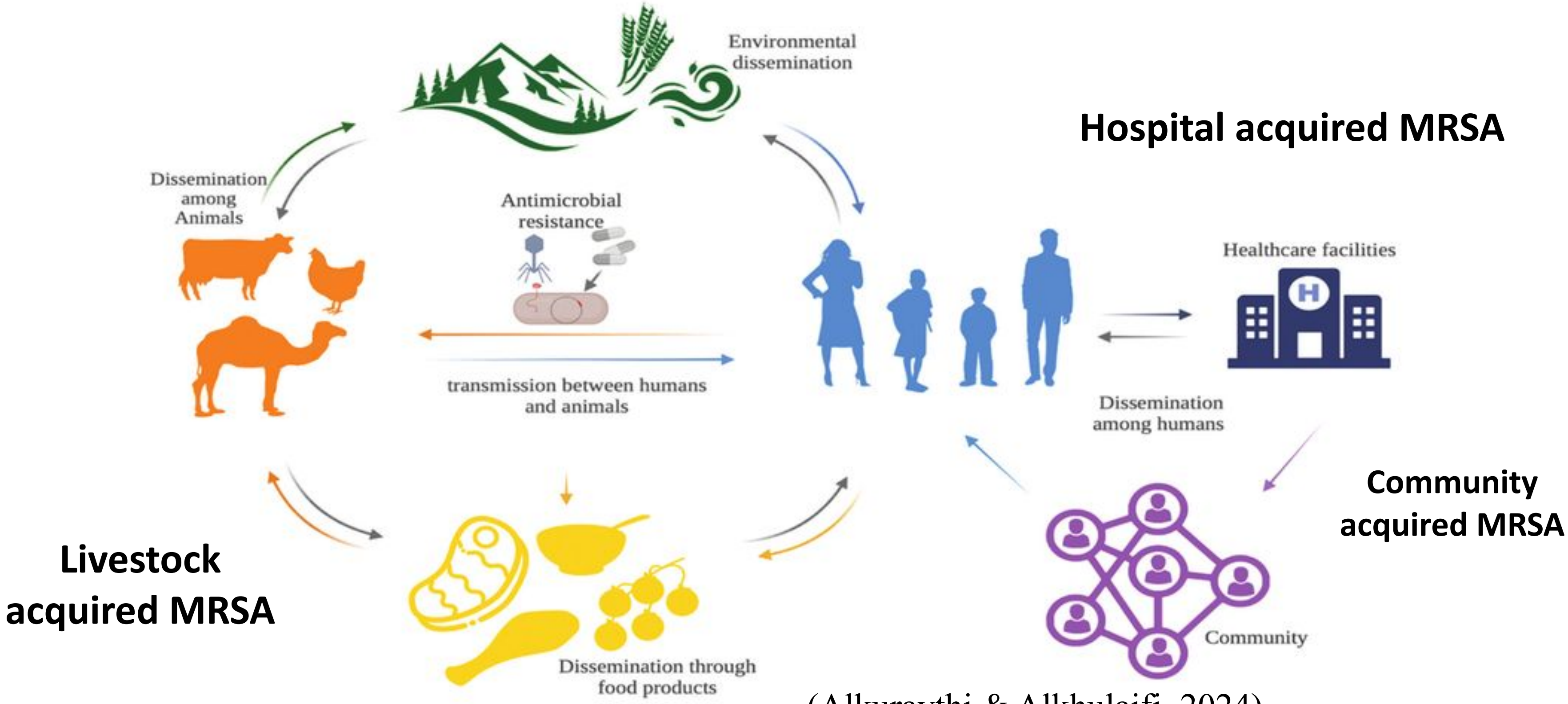
ZEWAIL CITY





http://dx.doi.org/10.1016/j.chom.2016.04.0
15

Staphylococcus aureus: Another One Health Perspective on Virulence, Resistance, and Host Adaptation

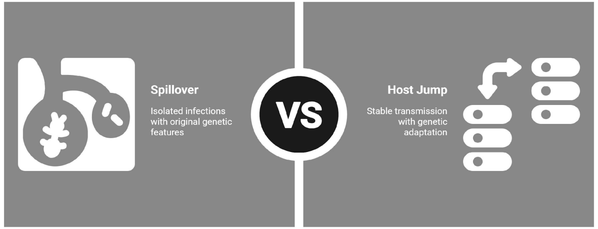


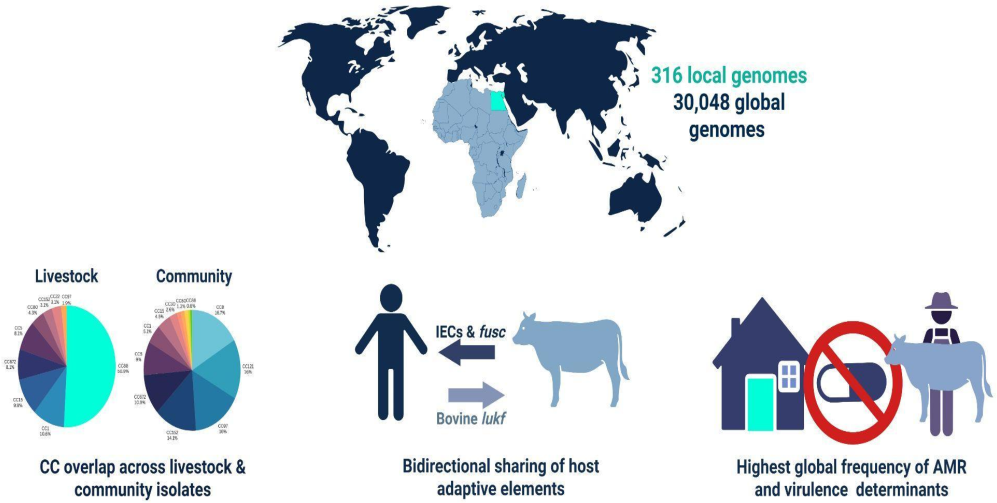
(Alkuraythi & Alkhulaifi, 2024)




Animal genomic scarcity: a global gap that weakens our understanding of cross-species transmission and host adaptation, especially in Africa

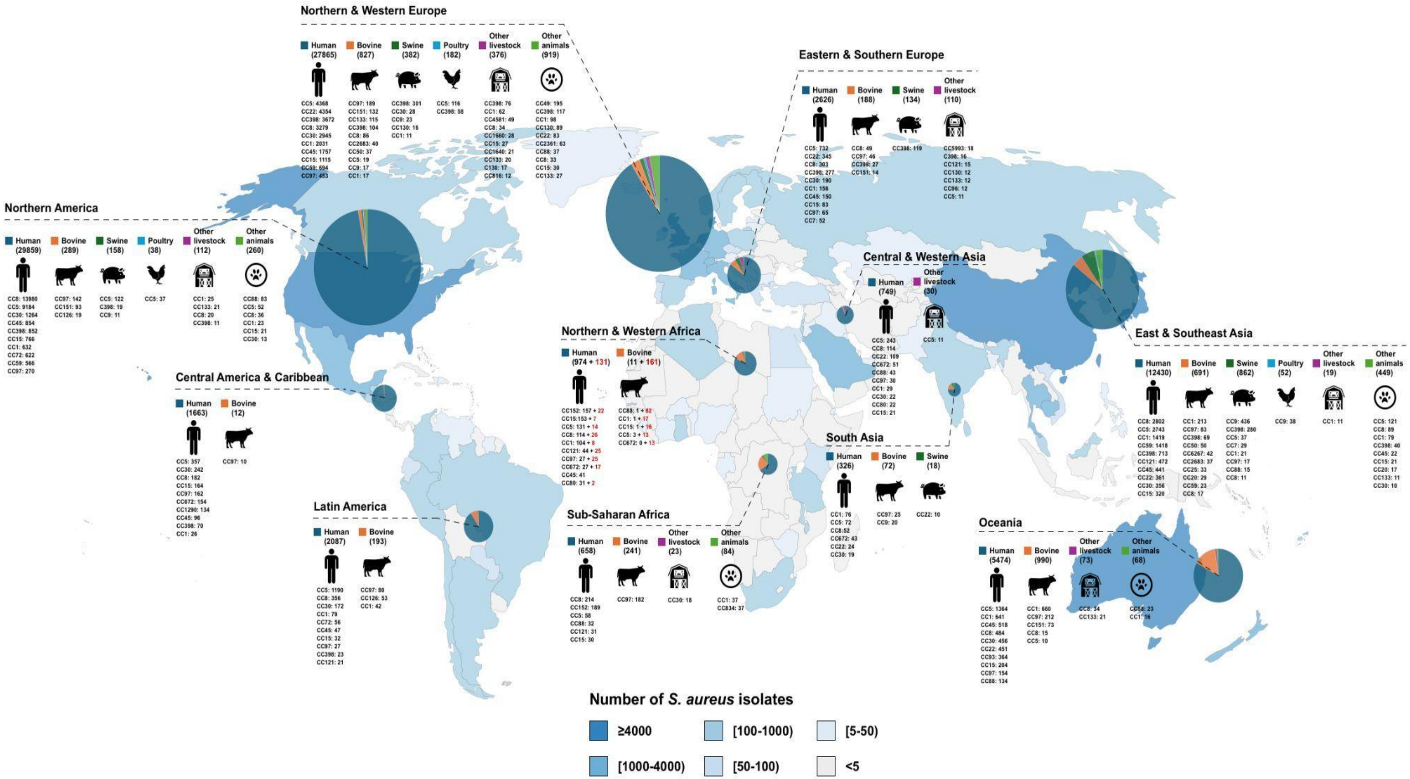
Choose the appropriate strategy for managing S. aureus transmission.



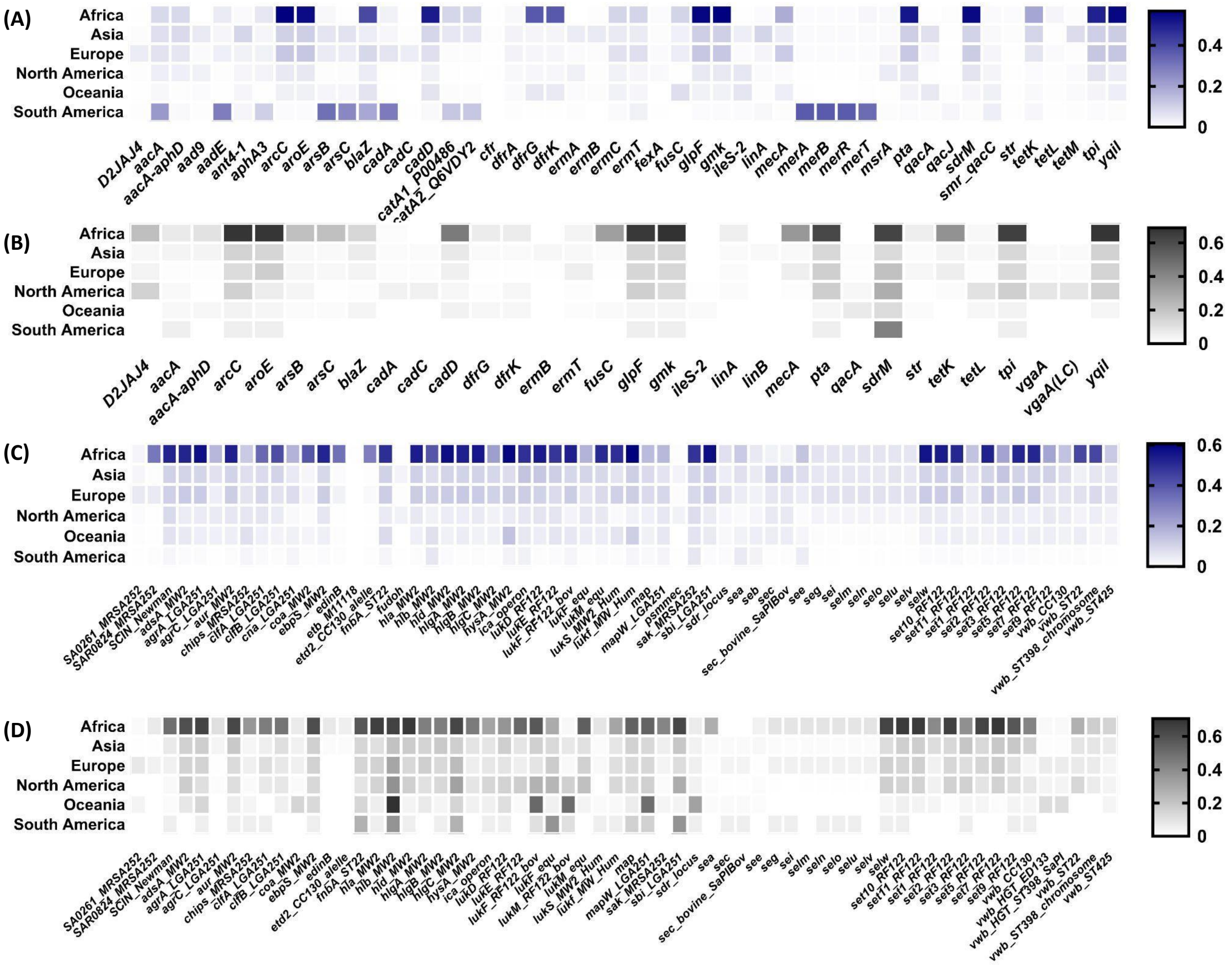


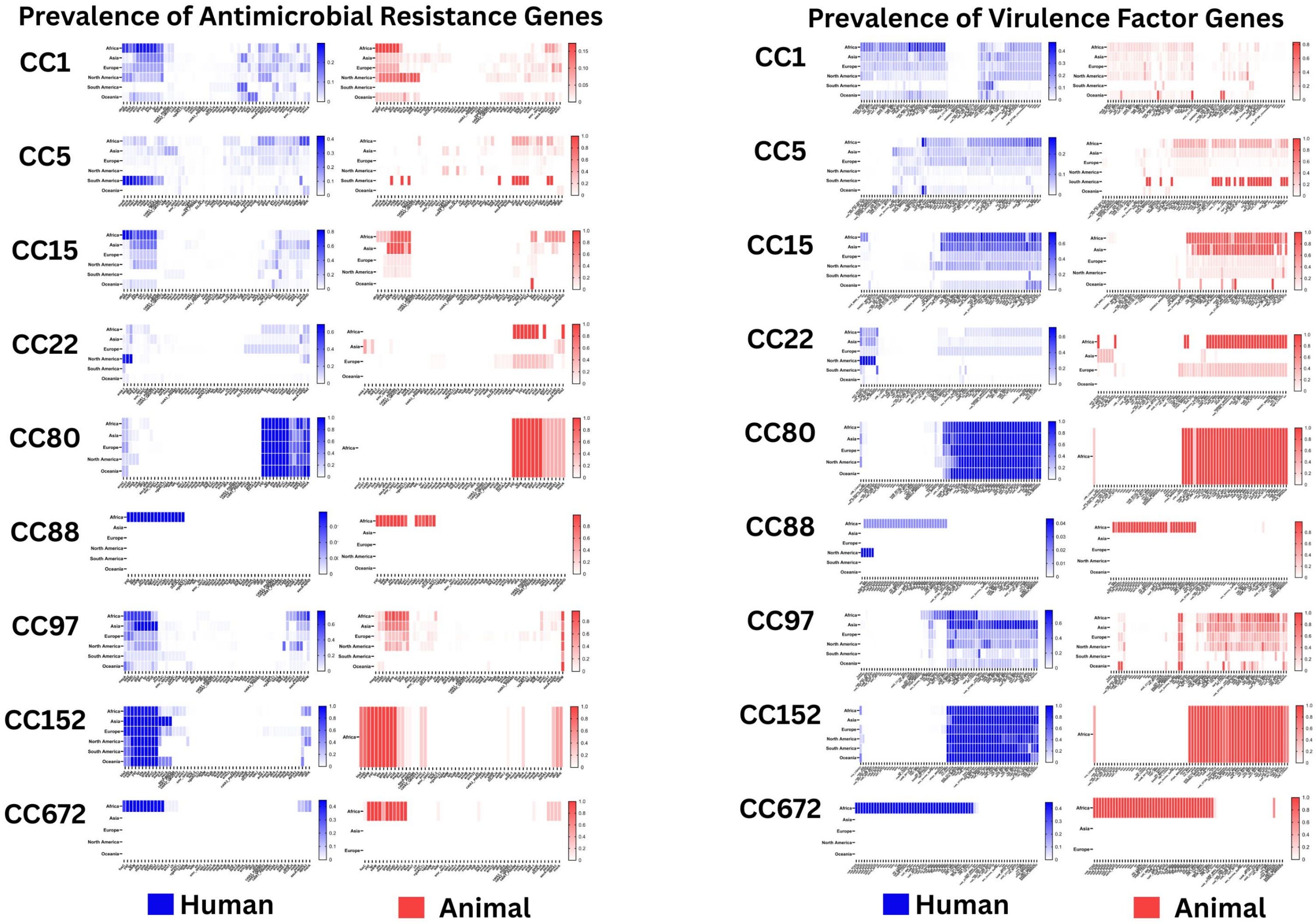
Africa has the least WGS data, yet shows the highest AMR and virulence gene frequencies and the greatest bidirectional sharing of host-adaptive elements between humans and animals

World map of S. aureus Genomic Studies



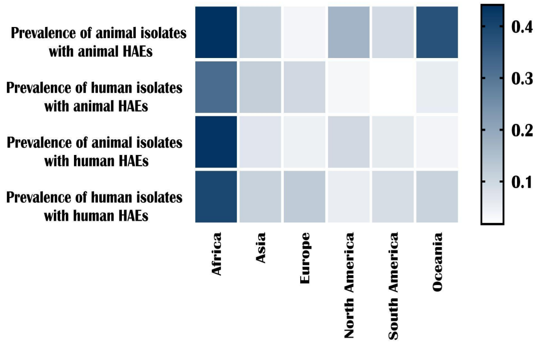
Prevalence of significant genetic markers across the globe
(A) ARGs in humans,
(B) ARGs in animals,
(C) VFGs in humans,
(D) VFGs in animals

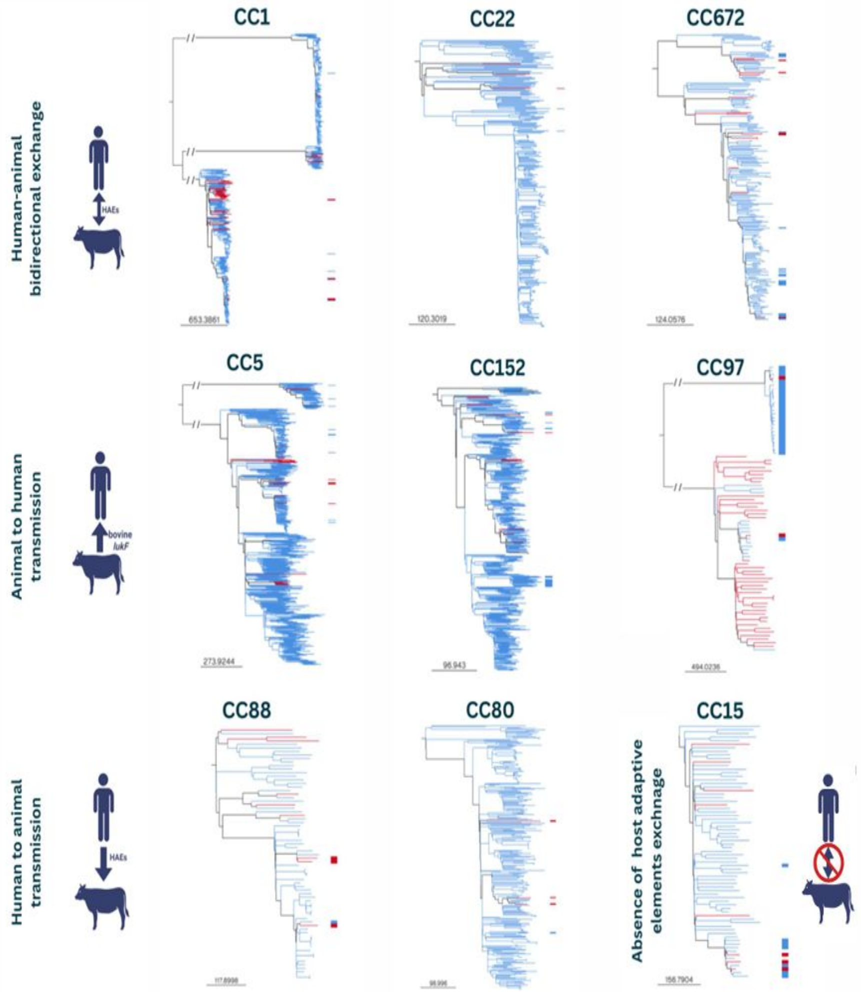



Prevalence of Antimicrobial Resistance Genes
Prevalence of Virulence Factor Genes
CC1
CC5
CC15
CC22
CC80
CC88
CC97
CC152
CC672
Africa
Asia
Europe
North America
South America
Oceania
Human
Animal

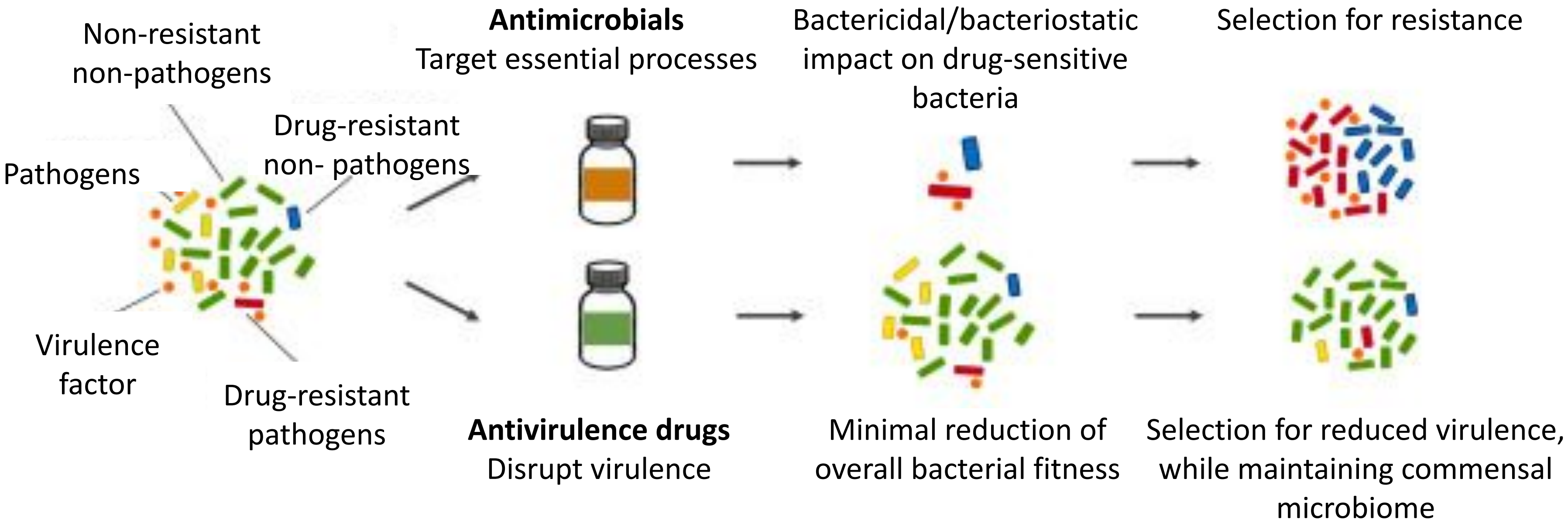
Global Phylogenies of *S. aureus* Shared Clonal Complexes among Human and Animal Isolates

Global Overview of *S. aureus* Host-Adaptive Elements (HAEs) Sharing Between Humans and Animals





Anti- virulence therapeutics: A New Frontier in Combating AMR



(Lau *et al.*, 2023)

GWAS-Driven Insights: Exploring New Dimensions of Bacterial Virulence and AMR



DATASET FOR GWAS

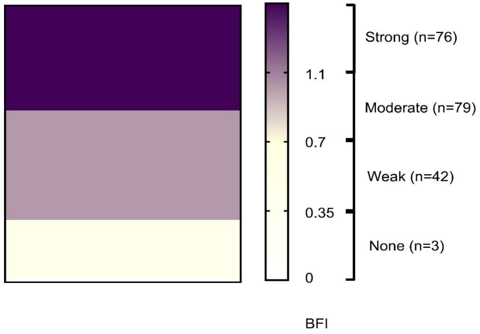
Center for Genomics

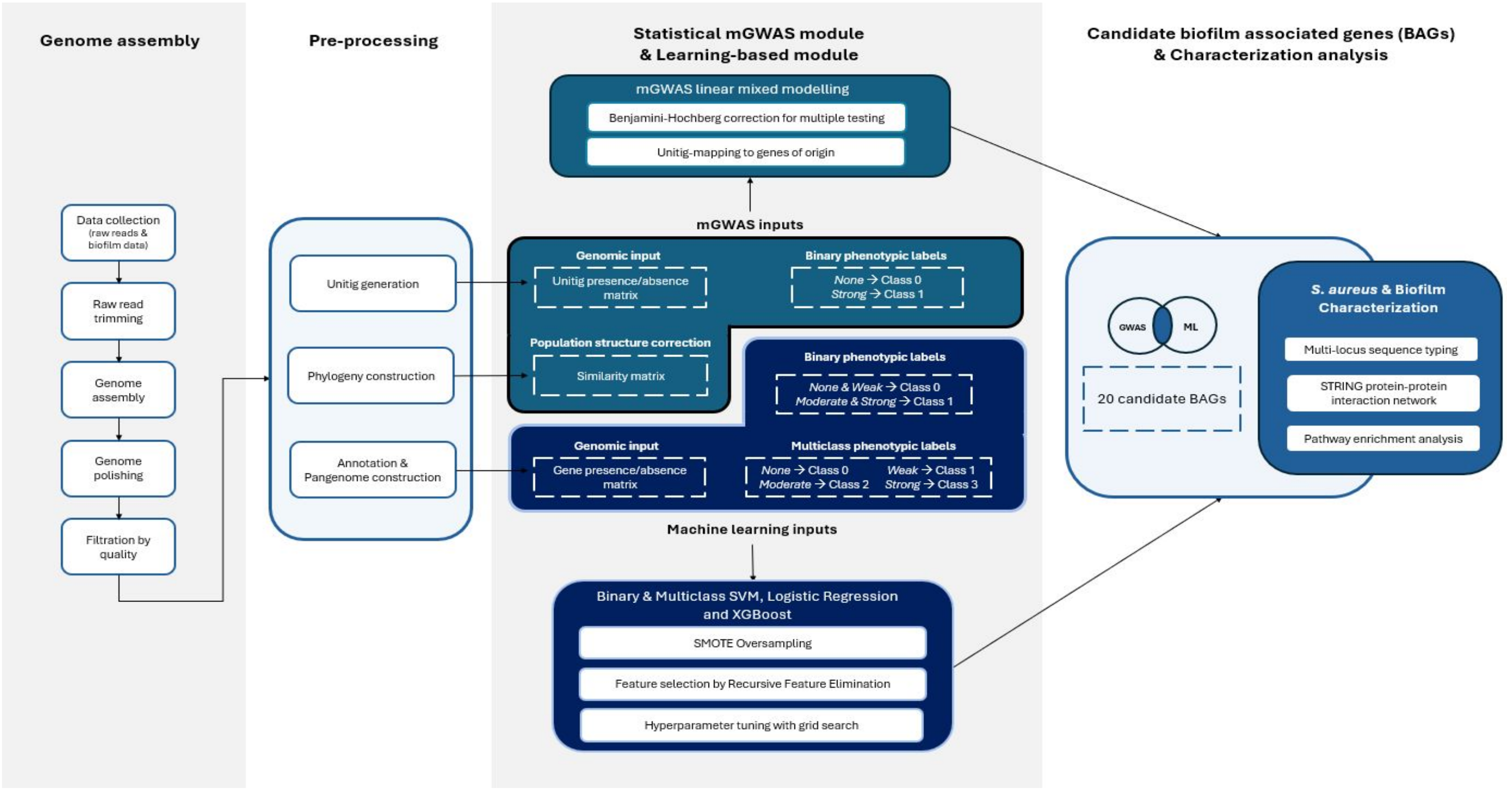
PRJNA648411

Genomic Data

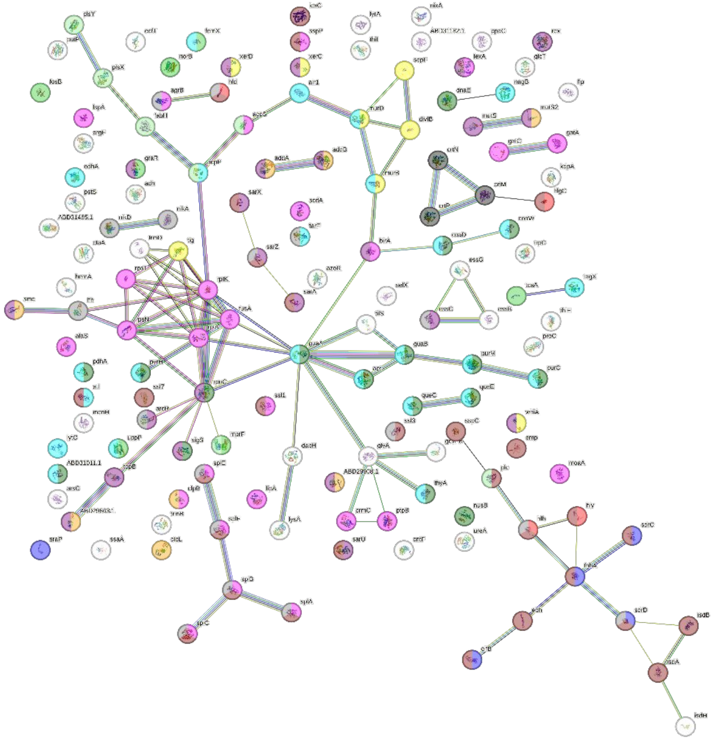
Total	**178**
CA-MRSA	115
HA-MRSA	63

Phenotypic Data

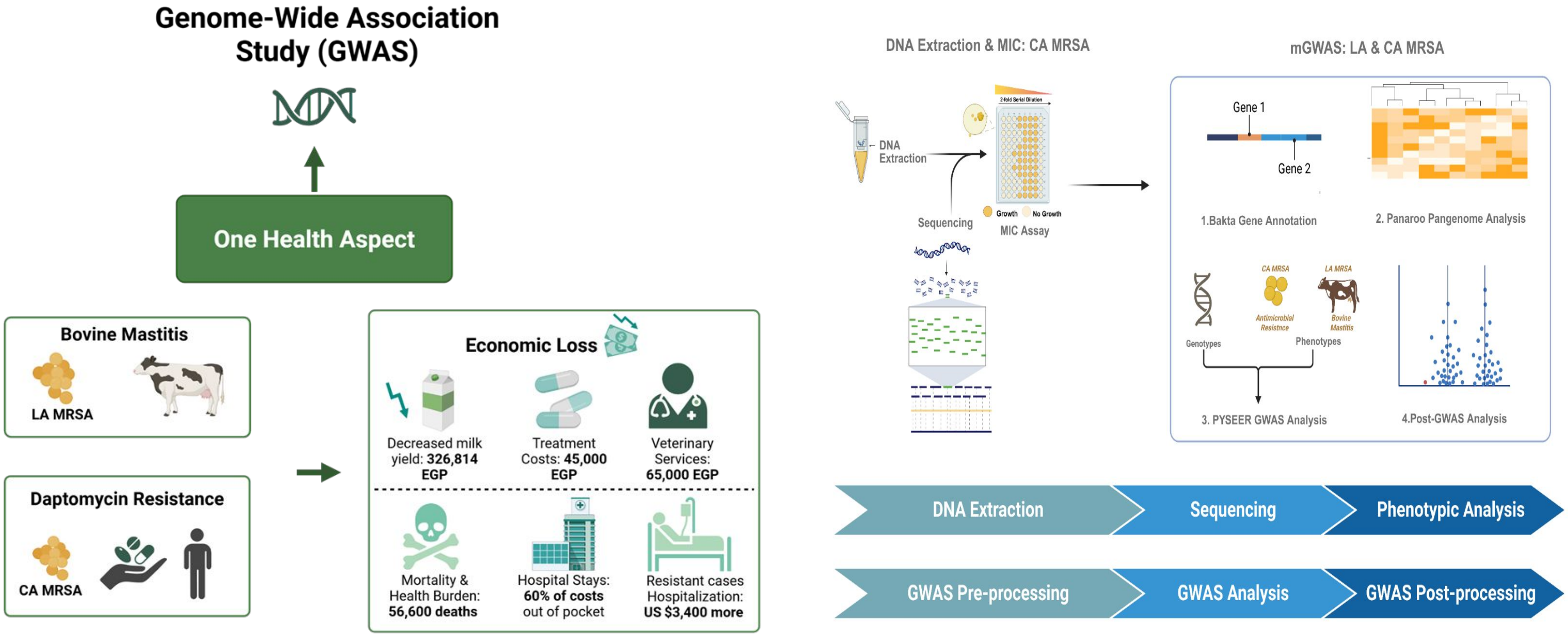



Genome assembly
Pre-processing
Statistical mGWAS module & Learning-based module
Candidate biofilm associated genes (BAGs) & Characterization analysis
Data collection (raw reads & biofilm data)
Raw read trimming
Genome assembly
Genome polishing
Filtration by quality
Unitig generation
Phylogeny construction
Annotation & Pangenome construction
mGWAS linear mixed modelling
Benjamini-Hochberg correction for multiple testing
Unitig-mapping to genes of origin
mGWAS inputs
Genomic input
Unitig presence/absence matrix
Binary phenotypic labels
None → Class 0
Strong → Class 1
Population structure correction
Similarity matrix
Binary phenotypic labels
None & Weak → Class 0
Moderate & Strong → Class 1
Genomic input
Gene presence/absence matrix
Multiclass phenotypic labels
None → Class 0
Weak → Class 1
Moderate → Class 2
Strong → Class 3
Machine learning inputs
Binary & Multiclass SVM, Logistic Regression and XGBoost
SMOTE Oversampling
Feature selection by Recursive Feature Elimination
Hyperparameter tuning with grid search
GWAS
ML
20 candidate BAGs
S. aureus & Biofilm Characterization
Multi-locus sequence typing
STRING protein-protein interaction network
Pathway enrichment analysis

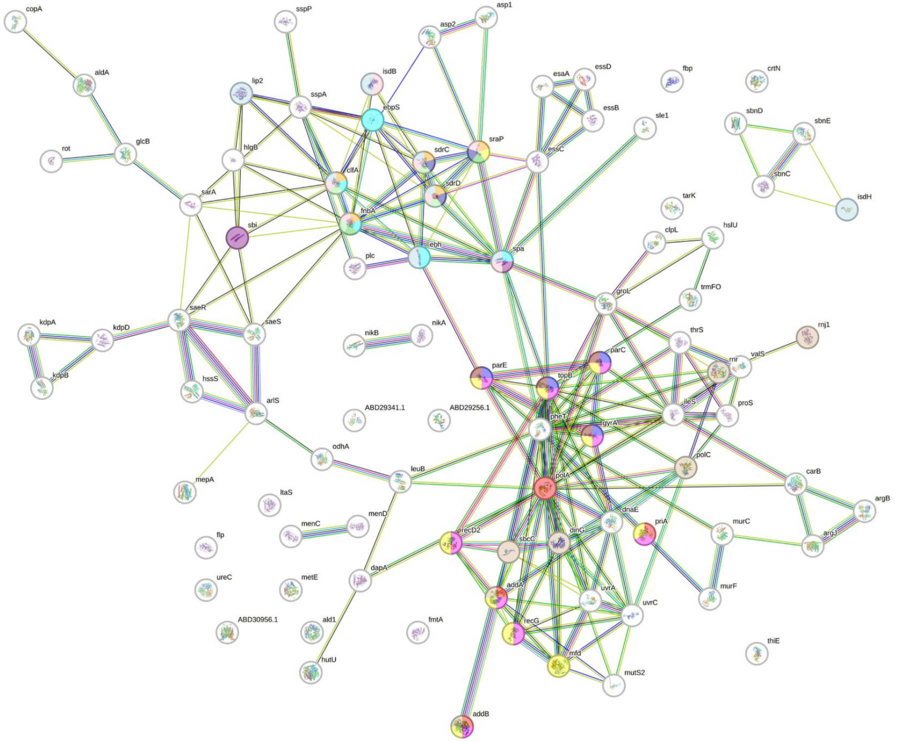
GWAS Identification of Genes Involved in Biofilm Formation

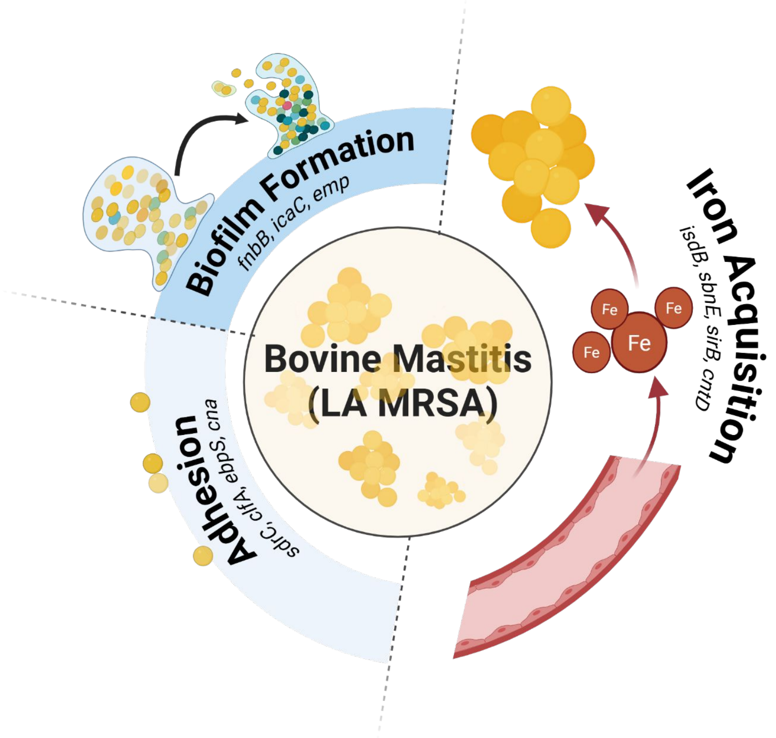


Transcription regulators	*sarX, ymcA*
Adhesins	*clfB, fnbA, emp, ebh*
Bacterial division in biofilms	*xerC, thyA, ftsK*
Biofilm structural maintenance	*pkrC*
Nutrient acquisition and transport	*Lysp-2, potB, nikA*


Genome-Wide Association Study (GWAS)
One Health Aspect
Bovine Mastitis
LA MRSA
Daptomycin Resistance
CA MRSA
Economic Loss
Decreased milk yield: 326,814 EGP
Treatment Costs: 45,000 EGP
Veterinary Services: 65,000 EGP
Mortality & Health Burden: 56,600 deaths
Hospital Stays: 60% of costs out of pocket
Resistant cases Hospitalization: US $3,400 more
DNA Extraction & MIC: CA MRSA
DNA Extraction
Sequencing
Growth
No Growth
MIC Assay
mGWAS: LA & CA MRSA
Gene 1
Gene 2
1.Bakta Gene Annotation
2. Panaroo Pangenome Analysis
CA MRSA
LA MRSA
Antimicrobial Resistnce
Bovine Mastitis
Genotypes
Phenotypes
3. PYSEER GWAS Analysis
4.Post-GWAS Analysis
DNA Extraction
Sequencing
Phenotypic Analysis
GWAS Pre-processing
GWAS Analysis
GWAS Post-processing

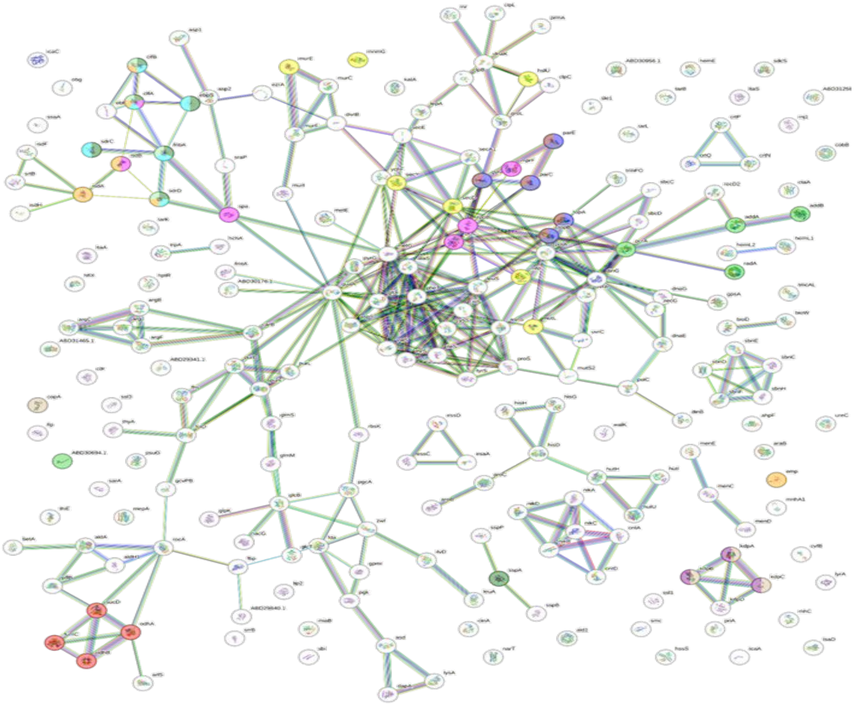
GWAS Identification of Genes Involved in Bovine Mastitis

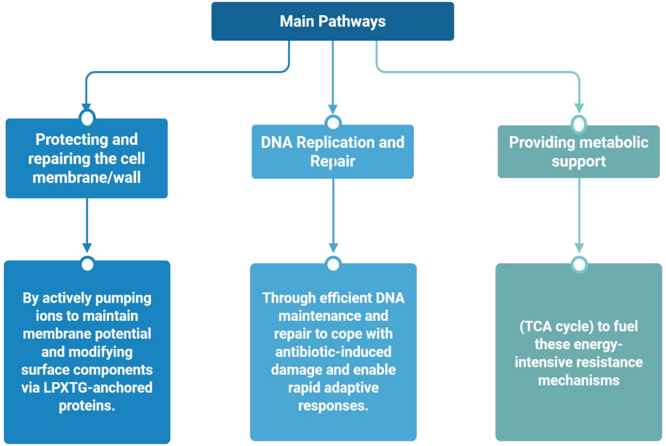




GWAS Identification of Genes Involved in Daptomycin Resistance

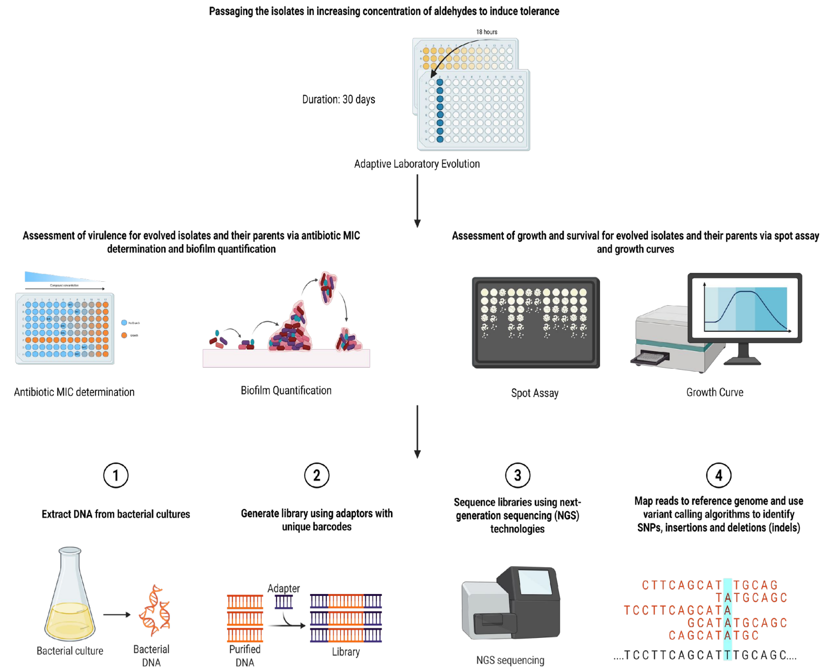


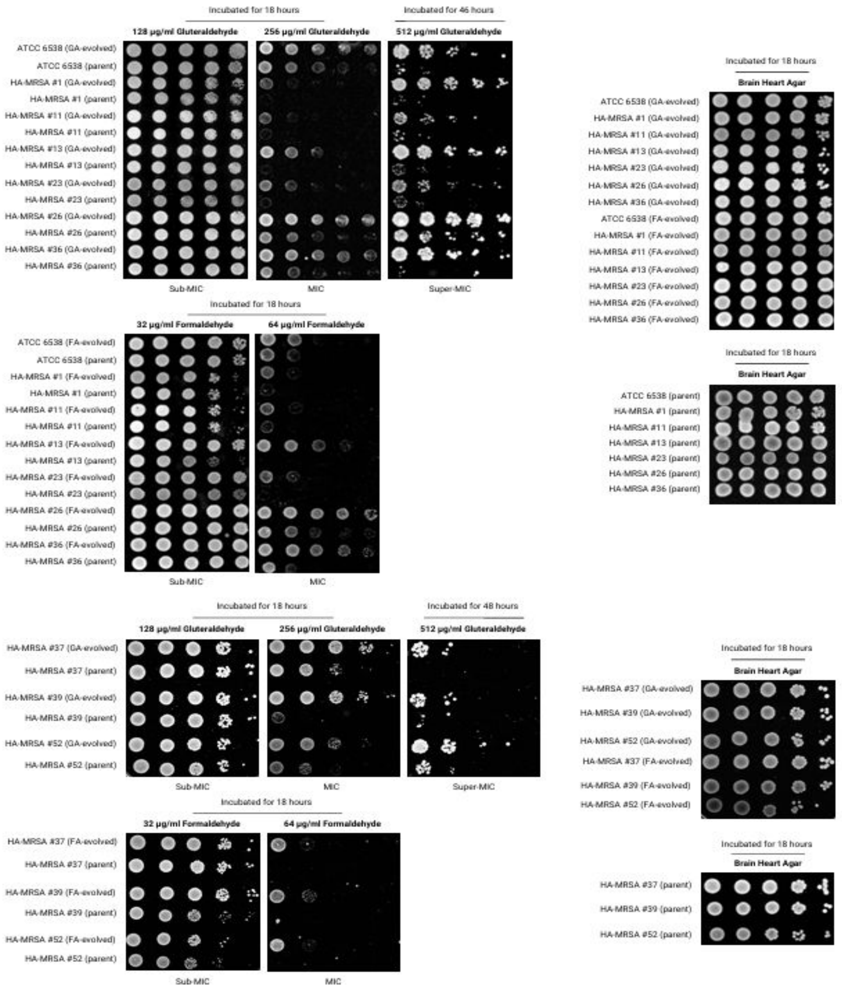


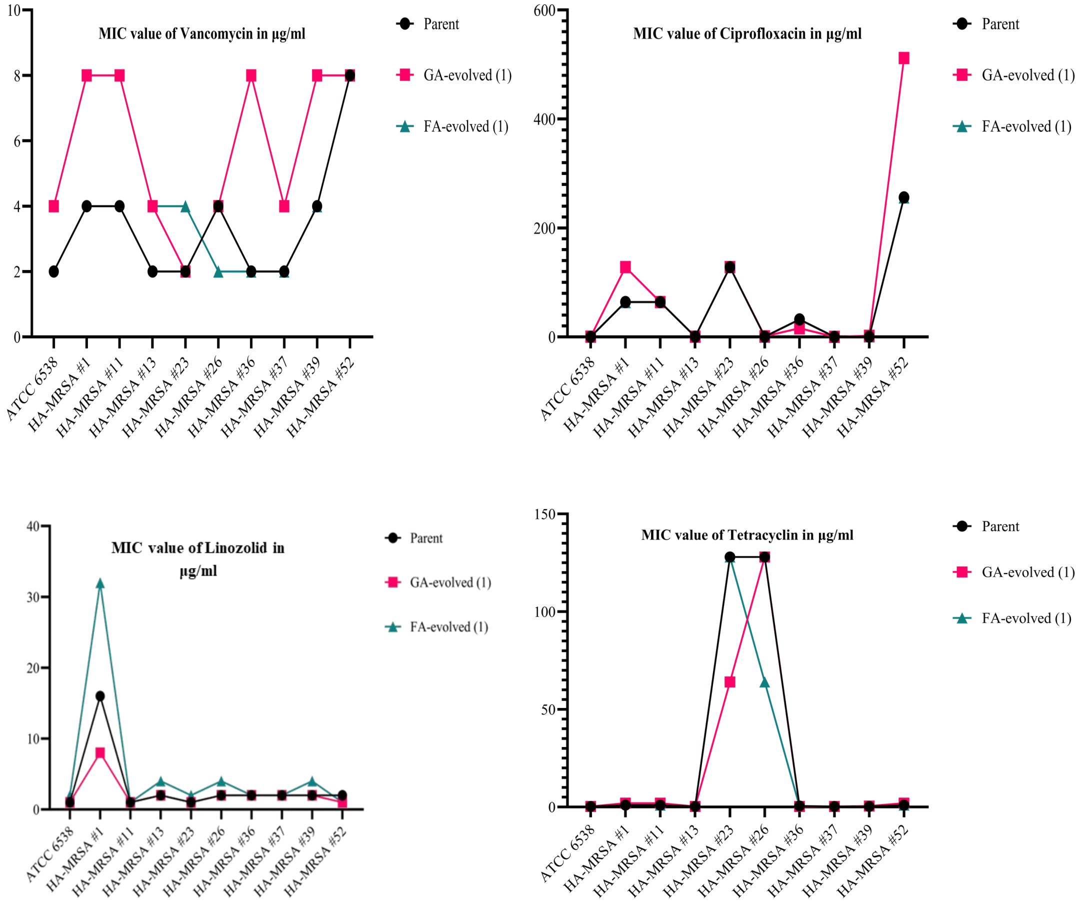




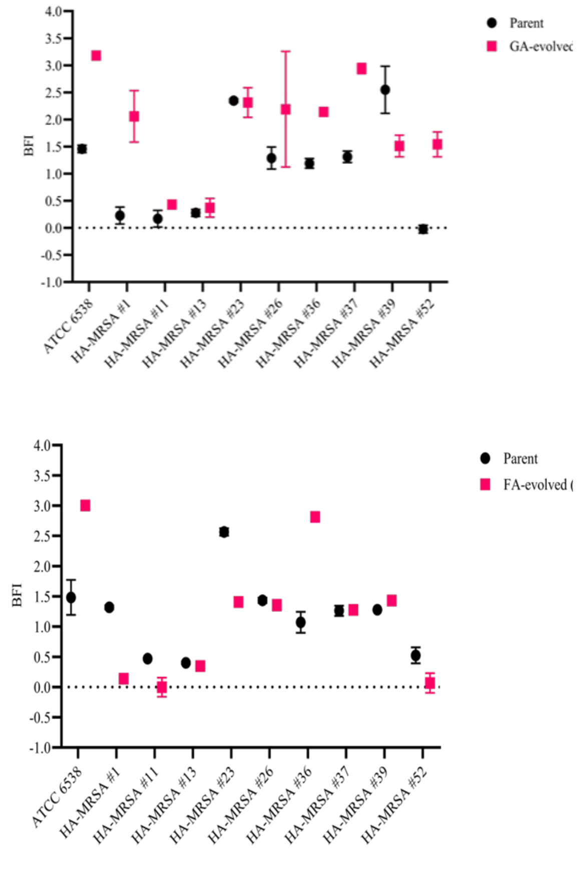

Biocides at the Crossroads: Evolution of Virulence and Resistance in MRSA







Tracing Evolution in Action: MIC Shifts in Evolved Isolates

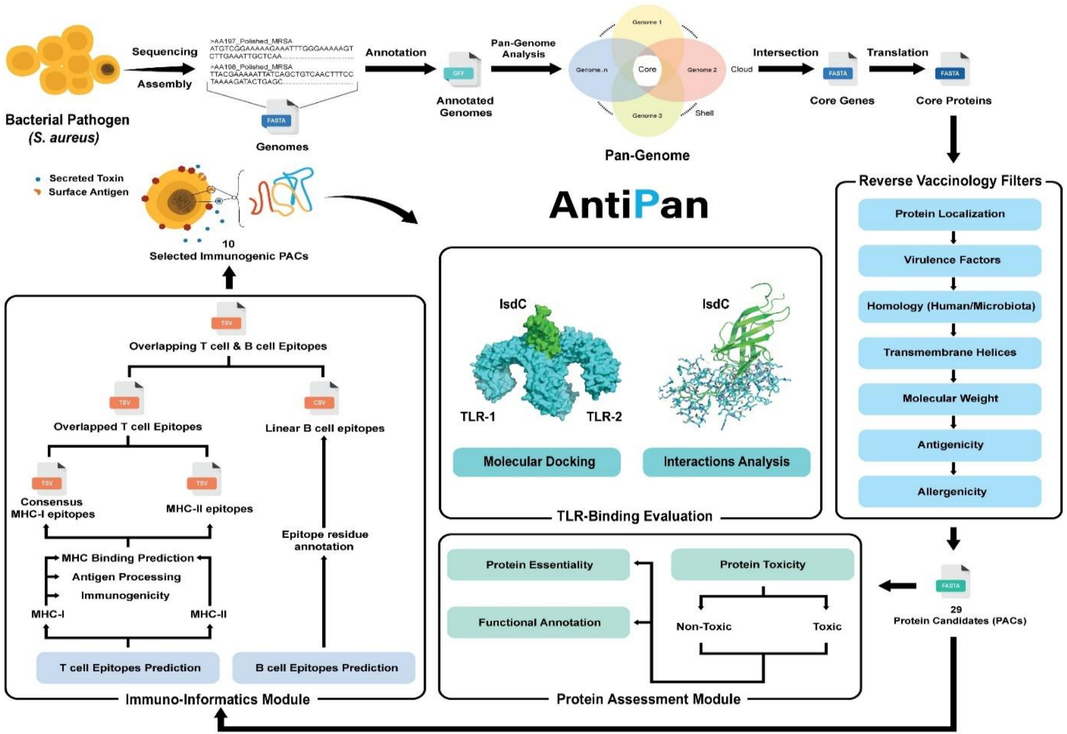


Evolved vs. Parental Isolates: Biofilm Formation Patterns

Genome sequences exist for hundred of thousands of strains, but…….

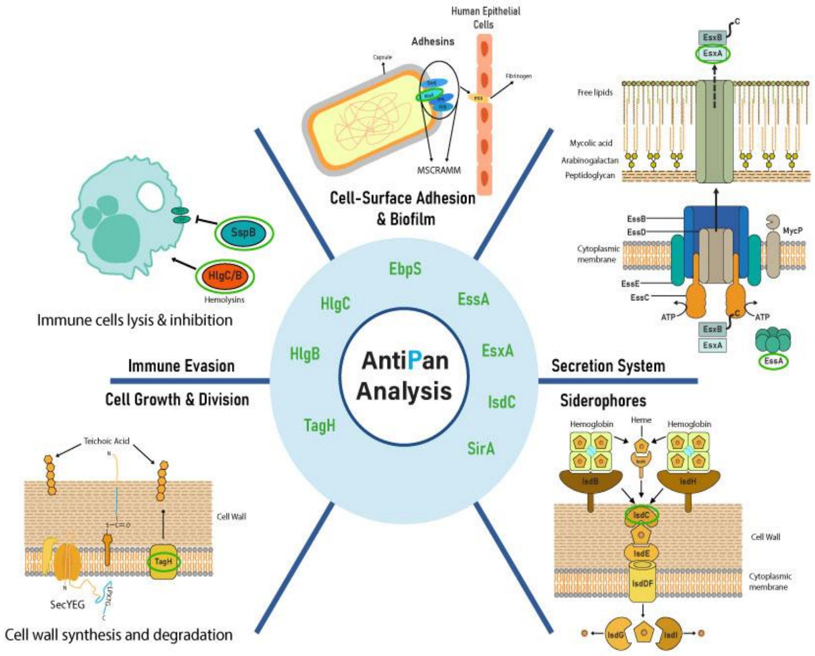
- What role do the encoded genes play in persistence and pathogenesis?
- Which molecules elect protective immunity?
- How conserved are key antigens or epitopes?
- How can we address such questions using minimal use of animals?

AntiPan: A Pilot study of Enhanced In-Silico Pipeline for Subunit Vaccine Discovery in Staphylococcus aureus



Name	Use	Link
Prokka 1.13	Prokaryotic genome annotation tool	GitHub: Prokka
Roary 1.0	Rapid large-scale prokaryote pangenome analysis Pipeline	GitHub: Roary
FastTree 2.1.9	Phylogenetic tree construction	Package Documentation: FastTree 2.1 GitHub: roary_plots.py
BLAST+ 2.14	Local alignment search for sequence similarity	Database Documentation: BLAST
PSORTb 3.0.3	Protein subcellular localization prediction	Server: PSORTb version 3.0
DeepTMHMM 1.0	Transmembrane topology prediction.	Server: DeepTMHMM 1.0
VFDB	Virulence factors database	Database Webpage: VFDB
UniProt-SwissProt	Protein sequence and function database	Database Webpage: UniProt
RefSeq	Human genome database for Homology search	Database Webpage: NCBI RefSeq
MvirDB	Microbial virulence database	Database Webpage: MvirDB
Vaxijen v2.0	Antigenicity prediction	Server: VaxiJen
AllerTOPv.2	Allergenicity prediction	Server: AllerTopv.2
IEDB T-cell epitopes prediction	T-cell epitopes prediction including MHC-I and MHC-II epitopes.	Package Database: IEDB
ToxinPred 2 & 3	Toxicity prediction of proteins & peptides.	Server: ToxinPred2 , Server: ToxinPred3.0
Bepipred 3.0	Linear B-cell epitopes prediction	Server: BepiPred 3.0
Eggnog 2.1.12	Orthology and functional annotation.	Database Webpage: eggNOG-mapper
DEG	Database of essential genes	Database Webpage: DEG

Identified Candidate Vaccine Proteins



Future insights

"Expanding scope, scaling innovation, and fostering global collaboration are essential to combat antimicrobial resistance effectively and sustainably"

Acknowledgments

UNIVERSITY OF BIRMINGHAM | BactiVac network

GAMRIF

ICGEB

CAMBRIDGE AFRICA

tiba

STDF
هيئة تمويل العلوم والتكنولوجيا والإبتكار

أكاديمية البحث العلمي والتكنولوجيا
ACADEMY OF SCIENTIFIC RESEARCH AND TECHNOLOGY

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ZEWAIL CITY
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INAUGURATED 2011

CSSP

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Enabling research by sharing knowledge

Department of BIOLOGY | UNIVERSITY OF OXFORD | INEOS OXFORD INSTITUTE | Department of BIOLOGY

LONDON SCHOOL of HYGIENE & TROPICAL MEDICINE

wellcome sanger institute

UNIVERSITY OF CAMBRIDGE

University of Regina

European Partnership on One Health Antimicrobial Resistance

Tackling the AMR challenge with a full circle approach

Popular pages: About EUP OHAMR > Partners > Joint transnational call 2026: New treatments to tackle AMR >

One Health research and innovation across borders to reduce the societal burden of antimicrobial resistance

The European Partnership on One Health Antimicrobial Resistance (EUP OHAMR) brings together 53 organisations from 30 countries in EU and beyond to address the challenges of antimicrobial resistance (AMR) across sectors and perspectives. The partnership deploys an integrated One Health approach, recognising that human, animal and plant health are interdependent and interlinked with the environment.

→ About EUP OHAMR

About EUP OHAMR

The European Partnership on One Health Antimicrobial Resistance (EUP OHAMR) brings together 53 organisations from 30 countries in EU and beyond, providing joint support to research and innovation and mobilising to address the challenges of antimicrobial resistance (AMR) with a One Health approach.

Antimicrobial resistance (AMR) is a global health challenge that affects human and animal health, food security and the environment. Immediate action is needed to boost AMR research and innovation (R&I) to better understand the biological mechanisms of resistance and evolution in microorganisms, as well as how AMR spreads, including social and human factors. There is a need for R&I to develop new treatments for infections and rapid and affordable diagnostics, and to improve current treatment solutions. New knowledge is also needed to improve surveillance methods and design innovative interventions to prevent and mitigate AMR.

Delivering R&I on this scale, and for impact, requires a collaborative and sustainable research community where capacities and assets are shared and used efficiently. Moreover, new knowledge must be implemented across many parts of the society to facilitate the translation and uptake of innovative solutions in real-word settings. Engagement from for example professional groups, civil society and regulators will be necessary to achieve sustainable change and impact.

Our Vision and Mission

Vision: To reduce the burden of antimicrobial resistance.

Mission: To boost One Health research and innovation leading to improved surveillance of resistant pathogens, better diagnostics and effective treatment of infections and to prevention measures reducing the use of antimicrobials and the spread of antimicrobial resistance.

Thank you!

Questions?

Antimicrobial Resistance from the One Health Lense

Dr. Heba Mahrous

One Health Technical Officer, WHO Regional Office for the Eastern Mediterranean (EMRO)

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One Health Technical Officer,
WHO Regional Office for the Eastern Mediterranean (EMRO)

Antimicrobial Resistance from the One Health Lense

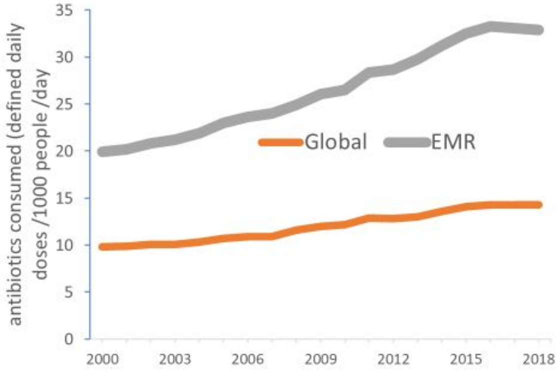
Dr. Heba Mahrous
Veterinary Epidemiologist, One Health Technical Officer
WHO Regional Office for the Eastern Mediterranean

MENA AMR Awareness Week 2025, November 21
Virtual webinar, 10:00-11:30 GMT

Global impact of AMR

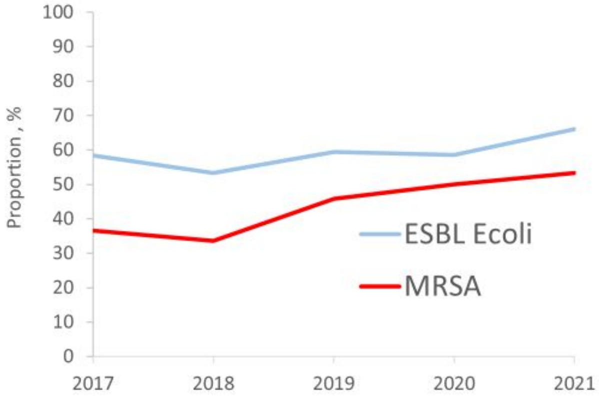
New estimates reveal that 39 million deaths directly attributable to bacterial antimicrobial resistance (AMR) will occur between 2025-2050 – which equates to three deaths every minute.

AMR in EMR



The highest and most rapidly rising antibiotic consumption

(GRAM data, 2000-2018)



Rising resistance rates

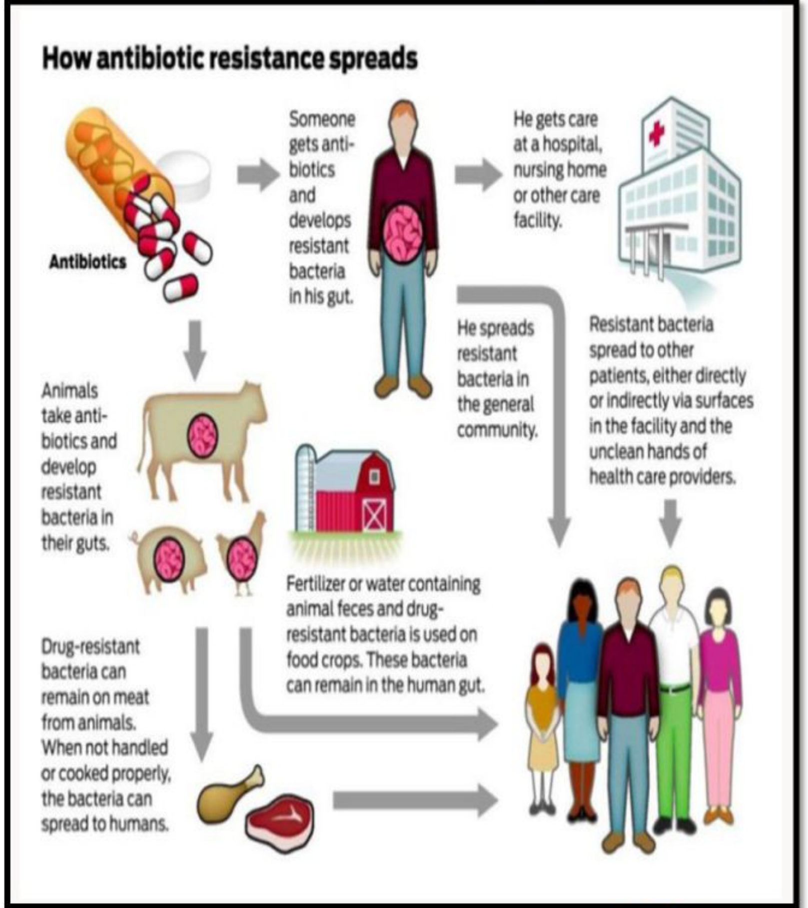
(GLASS data, 2017-2021)

World Health Organization
REGIONAL OFFICE FOR THE Eastern Mediterranean

HEALTH FOR ALL BY ALL a call for solidarity and action

Antimicrobial Resistance Drivers

- AMR diverse drivers can be separated into two components
  - ✓ **Selection**, predominantly by antimicrobial use and
  - ✓ **Transmission of resistant organisms** between each connected compartment on a human-animal-environment axis
- Improper and excessive use of antimicrobials
- Lack of access to clean water, sanitation, and hygiene for humans and animals
- Poor infection prevention and control measures in hospitals
- Poor access to medicines and vaccines
- Lack of awareness and knowledge
- and irregularities with legislation



SOURCES: Topp presentation, June 20, 2017; Todd Trumbull/San Francisco Chronicle/Polaris; adapted from CDC, 2013a.National Academies of Sciences, Engineering, and Medicine. 2017. The National Academies Press. https://doi.org/10.17226/24914.

One Health Concept

Food and Agriculture Organization of the United Nations
OIE WORLD ORGANISATION FOR ANIMAL HEALTH
World Health Organization
UN environment programme

The Manhattan Principles on "One World, One Health"

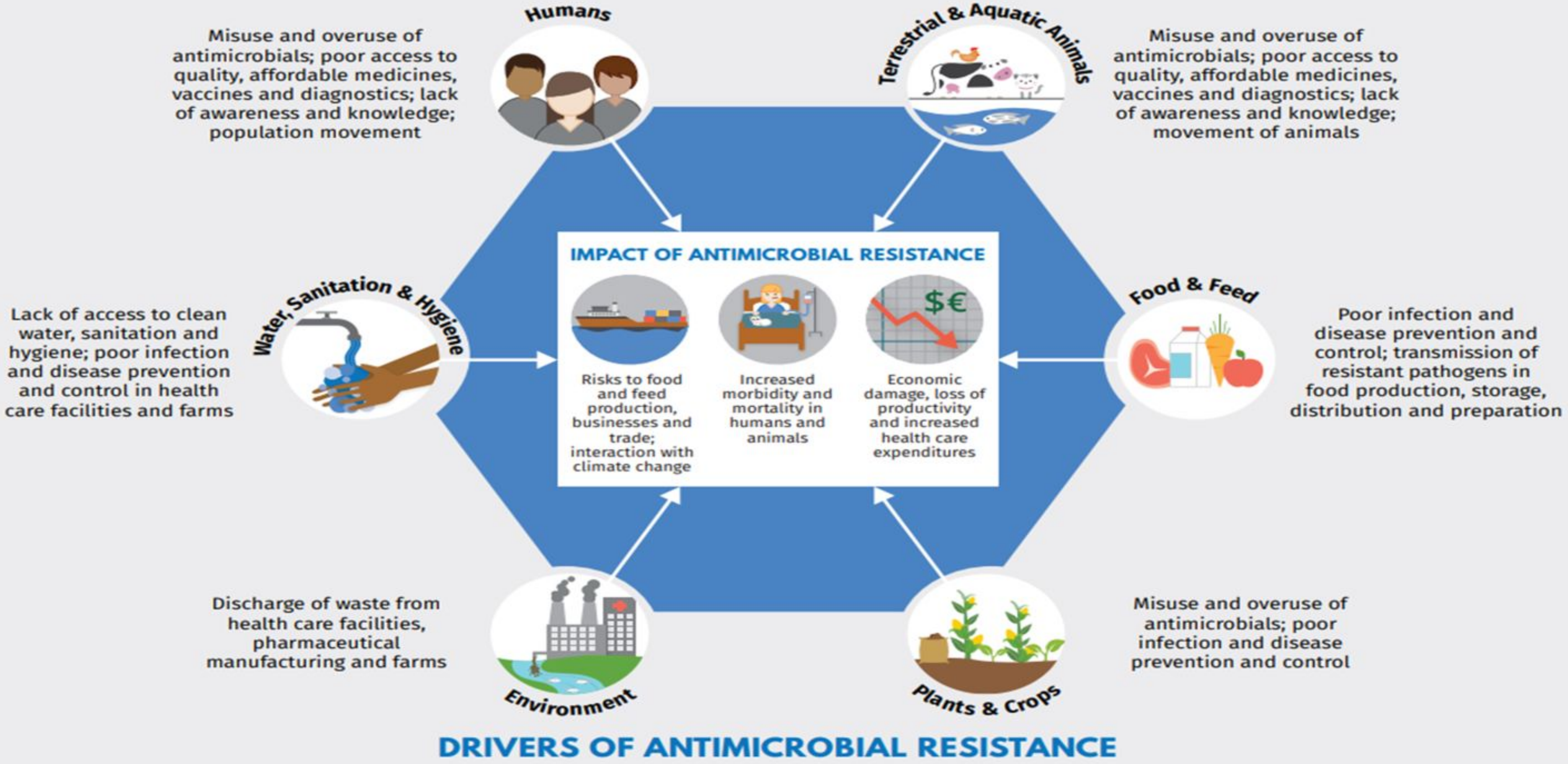
- The concept of One Health was officially launched in September 2004, in New York
- At the conference "One World, One Health: Building Interdisciplinary Bridges to Health in a Globalized World"

- Is an integrated unifying approach which recognizes that the health of humans, domestic and wild animals, plants and our ecosystems are closely linked and inter-dependent.

- One Health ramifications go far beyond infectious diseases, it becomes a key approach for food safety, non-communicable diseases and AMR that threaten the achievement of the SDGs' targets on health, environment, economic development and sustainable production and consumption.

Fig 1. A One Health response to address the drivers and impact of antimicrobial resistance

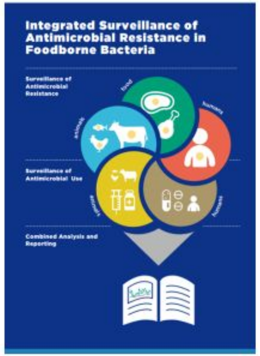
"One Health" refers to designing and implementing programmes, policies, legislation and research in a way that enables multiple sectors and stakeholders engaged in human, terrestrial and aquatic animal and plant health, food and feed production and the environment to communicate and work together to achieve better public health outcomes.

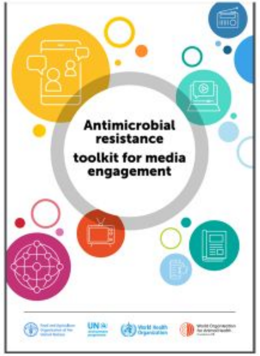


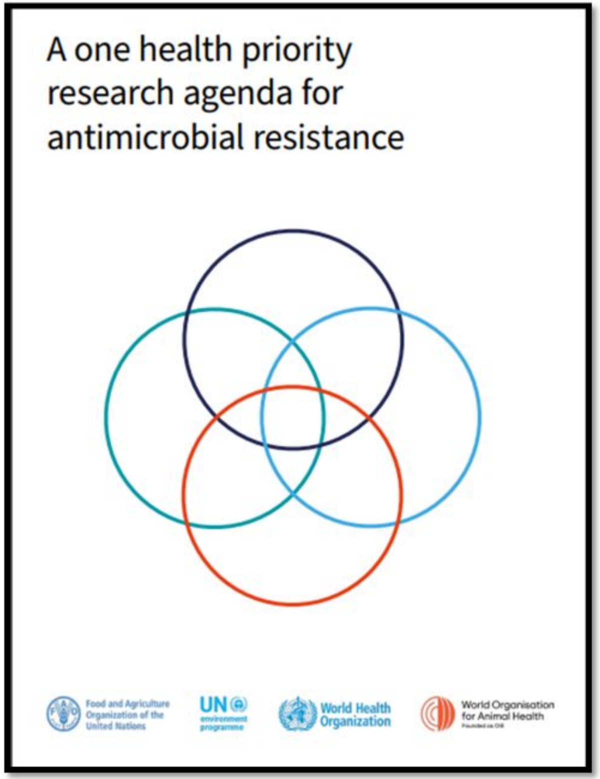
Global efforts towards combating AMR

Mission and Vision

- Working to preserve antimicrobial efficacy and ensure sustainable and equitable access to antimicrobials in human, animal and plant health, thereby furthering progress on the Sustainable Development Goals (SDGs).



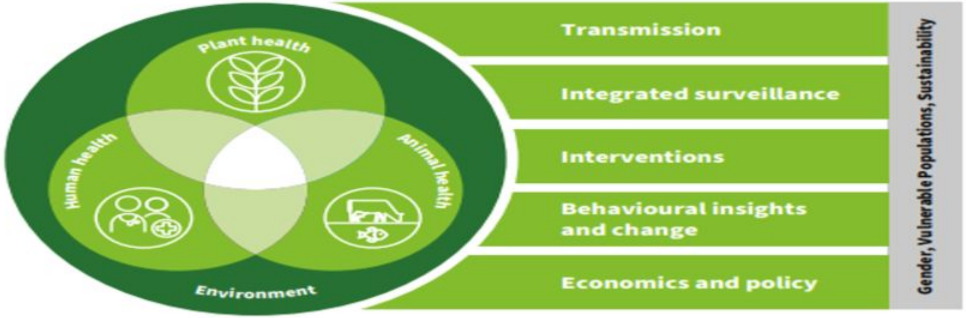


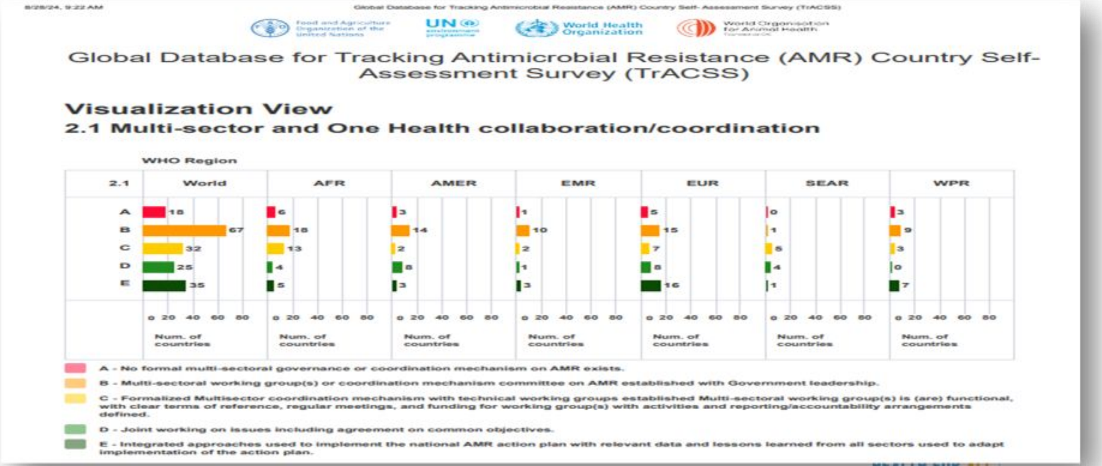


A one health priority research agenda for antimicrobial resistance

Food and Agriculture Organization of the United Nations | UN environment programme | World Health Organization | World Organisation for Animal Health

Figure 3: The Five Pillars of the One Health Priority Research Agenda for Antimicrobial Resistance





Global Database for Tracking Antimicrobial Resistance (AMR) Country Self-Assessment Survey (TrACSS)

Visualization View

2.1 Multi-sector and One Health collaboration/coordination

WHO Region (Num. of countries)

2.1	World	AFR	AMER	EMR	EUR	SEAR	WPR
A	18	6	3	1	5	0	3
B	67	18	14	10	15	1	9
C	32	13	2	2	7	5	3
D	25	4	8	1	8	4	0
E	35	5	3	3	16	1	7

A - No formal multi-sectoral governance or coordination mechanism on AMR exists.

B - Multi-sectoral working group(s) or coordination mechanism committee on AMR established with Government leadership.

C - Formalized Multisector coordination mechanism with technical working groups established Multi-sectoral working group(s) is (are) functional, with clear terms of reference, regular meetings, and funding for working group(s) with activities and reporting/accountability arrangements defined.

D - Joint working on issues including agreement on common objectives.

E - Integrated approaches used to implement the national AMR action plan with relevant data and lessons learned from all sectors used to adapt implementation of the action plan.

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HEALTH FOR ALL BY ALL a call for solidarity and action

Growing political momentum

WHA 69.23 (2016): “Combatting antimicrobial resistance” encourages member states to adopt national action plans using a One Health approach (humans, animals, environment).

- The **3rd High-level Ministerial Conference on AMR**, hosted by Oman in November 2022
- Concluded with the **Muscat Ministerial Manifesto**, which outlines three global targets to reduce antimicrobial consumption in the human and animal health sector.
- **16 EM countries have signed up to the manifesto!**

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The 4th Global High-Level Ministerial Conference on AMR

- ✓ In KSA in November 2024.
- ✓ A key outcome of this conference is the launch of the AMR One Health Learning Hub in Saudi Arabia, Supported by WHO
- ✓ Build skills across sectors, align national and global efforts, and accelerate practical implementation of multisectoral national action plans, to combat AMR through a One Health approach.

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One Health Joint Plan of Action (OHJPA)

Action Track 1: Enhancing One Health capacities to strengthen health systems

Action Track 6: Integrating the Environment into One Health

Action Track 2: Reducing the risks from emerging and re-emerging zoonotic epidemics and pandemics

Action Track 5: Curbing the silent pandemic of Antimicrobial Resistance (AMR)

Action Track 3: Controlling and eliminating endemic zoonotic, neglected tropical and vector-borne diseases

Action Track 4: Strengthening the assessment, management and communication of food safety risks

One Health Regional activities

Joint Statement of Intent

2nd June 2025
Endorsement of the Joint Statement of Commitment among the Regional Directors/ Representatives of the Quadripartite

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One Health Regional Quadripartite Action Plan

Purpose

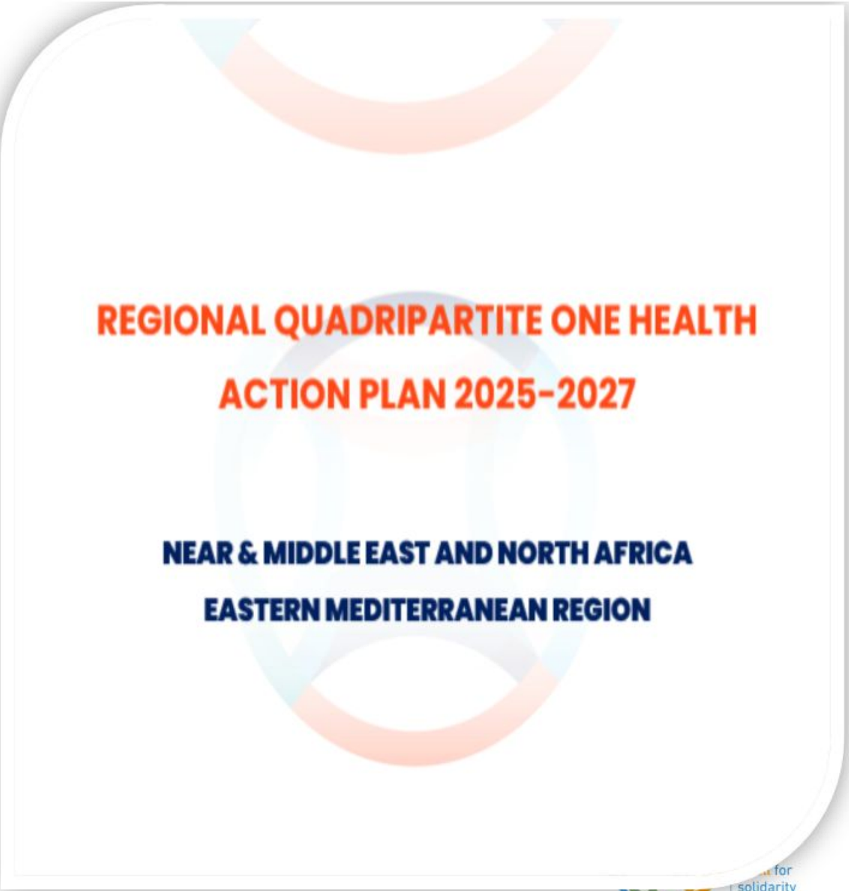
- To advance the OH implementation at regional and national level, to detect, prevent, and respond to health threats at the human-animal-environment interface using the One Health approach through collaborative efforts.

Operational objectives

- **Implement a comprehensive regional mechanism** that establishes multisectoral approaches to enhance the health of humans, animals, and environment.

- **Efficiently and effectively use the OH approach in the prevention and control of health threats** at the human-animal-environment interface which will minimize their negative consequences on the health system and well-being.

- **Promote the use of technology and tools for joint OH practices, enhancing data integration and information-sharing** across sectors at the national and regional levels.


REGIONAL QUADRIPARTITE ONE HEALTH ACTION PLAN 2025-2027

NEAR & MIDDLE EAST AND NORTH AFRICA

EASTERN MEDITERRANEAN REGION

One Health Regional Quadripartite Coordination Mechanism

Regional One Health Executive Committee (Regional OHEC)

Represented by Respective Regional Heads of the Quadripartite organizations

Regional One Health Coordination Group (Regional OHCG)

One Health focal points from FAO, UNEP, WHO and WOAH coordinate among the different technical working groups and the steering committee

Regional One Health Technical Groups (Regional OHTG)

Technical officers from each Quadripartite organization. The scope of the OHTG for One Health approach covers zoonotic diseases, food safety, and AMR.

Meetings either virtual or hybrid

Annually	Monthly	Every 2-3 Monthly

(Regional OHEC) ← Annually ← **(Regional OHCG)**

Key One Health Strategies Against AMR

Surveillance: Integrated surveillance for monitoring of resistance in humans, animals, and the environment.

Stewardship: Rational use of antimicrobials across sectors, including restrictions on growth promoters in agriculture (animal sector).

Infection prevention: Strengthening hygiene, vaccination, and biosecurity measures to reduce reliance on antibiotics.

Research and innovation: Developing alternatives such as vaccines, probiotics, and rapid diagnostics.

Multisectoral coordination: National action plans that align human health, veterinary, and environmental regulations.

Act Now: Protect Our Present, Secure Our Future

Thank you

شكرا جزيلا

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a call for solidarity and action

Antimicrobial Resistance Support to Countries

Dr. Shaffi Fazaludeen Koya

Medical Officer, AMR/IPC/One Health Unit,
Department of Health Promotion, Disease Prevention & Control, WHO Regional Office for the Eastern Mediterranean

Dr. Shaffi Fazaludeen Koya

Medical Officer, AMR/IPC/One Health Unit, Department of Health Promotion, Disease Prevention & Control, WHO Regional Office for the Eastern Mediterranean

Antimicrobial resistance: MENA regional progress and priorities

Dr Shaffi Fazaludeen Koya DrPH, MBBS, MPH,MBA

Medical Officer, AMR-IPC-One Health Unit

Department of Health Promotion, Disease Prevention & Control

World Health Organization

REGIONAL OFFICE FOR THE Eastern Mediterranean

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The content does not constitute official WHO policy or guidance unless explicitly stated.

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Magnitude and Impact of AMR

- AMR is **one of the greatest threats to modern medicine**
  - OECD predicts that, between 2015-2050, **2.4 million** people could die in Europe, North America and Australia due to superbug infections. Figures are much higher globally[1].

- In some countries, **more than 40% of infections** are due to bacteria that are resistant to antibiotics.

- Economic damage of uncontrolled resistance by 2050 will be **comparable to the 2008-2009 global financial crisis**
  - Up to **3.5%** fall in global GDP[2].

Source:
1. OECD. Stemming the Superbug Tide: Just a Few Dollars More. *OECD Publishing, Paris*. 2018
2. World Bank Group. (2017). Drug-Resistant Infections: A Threat to Our Economic Future. Available at: http://documents.worldbank.org/curated/en/323311493396993758/pdf/final-report.pdf

Antimicrobial resistance is a major threat to global health

Current and future impact of AMR

1
child dies every **3 min** from MDRO sepsis[1]

1.3 million deaths attributable to AMR per year[2]

28 million people living in poverty by 2050[3]

US$ 1 trillion additional healthcare costs by 2050[3]

7.5% decline in livestock by 2050[3]

1. Ramanan Laxminarayan et al. Lancet. 2016; 387: 168-175;

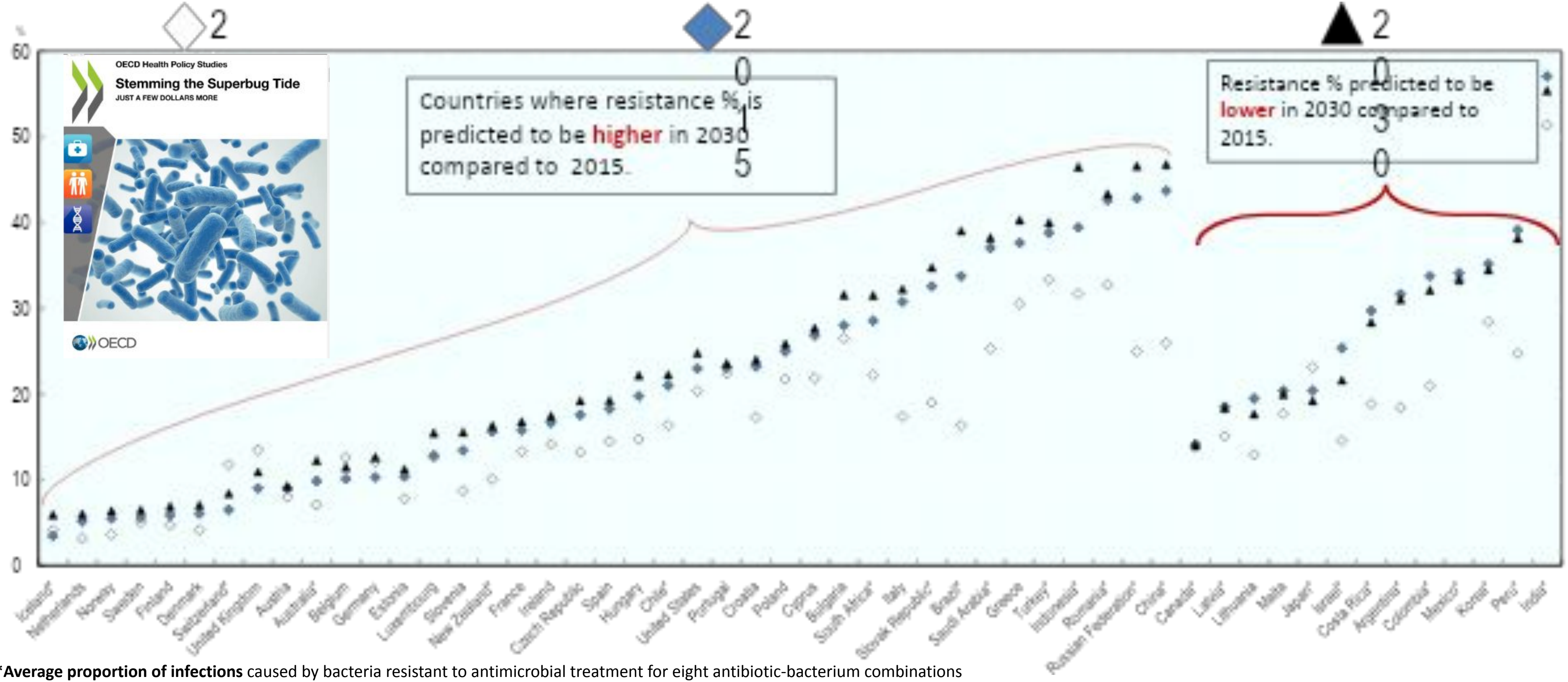
2. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. The Lancet 2022 https://www.sciencedirect.com/science/article/pii/S0140673621027240?via%3Dihub;

3. https://www.worldbank.org/en/topic/health/publication/drug-resistant-infections-a-threat-to-our-economic-future

Resistant infections rising globally

World Health Organization

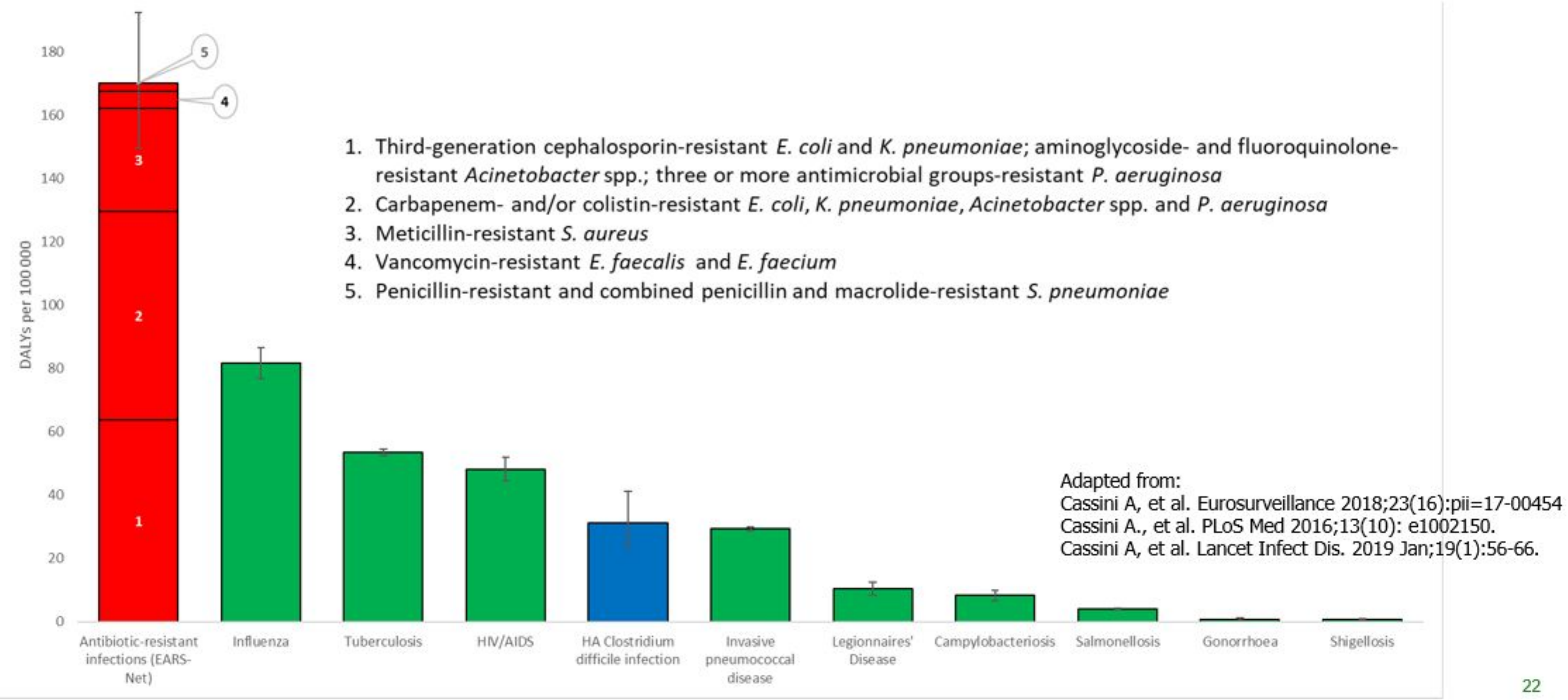
In 42 out of the 52 countries below, proportion of infections caused by resistant bacteria* increased from 2005-2015



***Average proportion of infections** caused by bacteria resistant to antimicrobial treatment for eight antibiotic-bacterium combinations

Source: OECD. (2018) Stemming the Superbug Tide: Just a Few Dollars More (p. 92)..)

BURDEN IS COMPARABLE TO THE COMBINED BURDEN OF INFLUENZA, TB & HIV/AIDS



22

Courtesy: Cassini A.

Background

Antimicrobials have increased the average human lifespan by **23 years** *(Hutchings et al, Current Opin in Micr, 2019)*

Increasing AMR threatens to reverse gains made in management of infectious diseases

Driven mainly by increased **consumption of antimicrobials** in humans and animals

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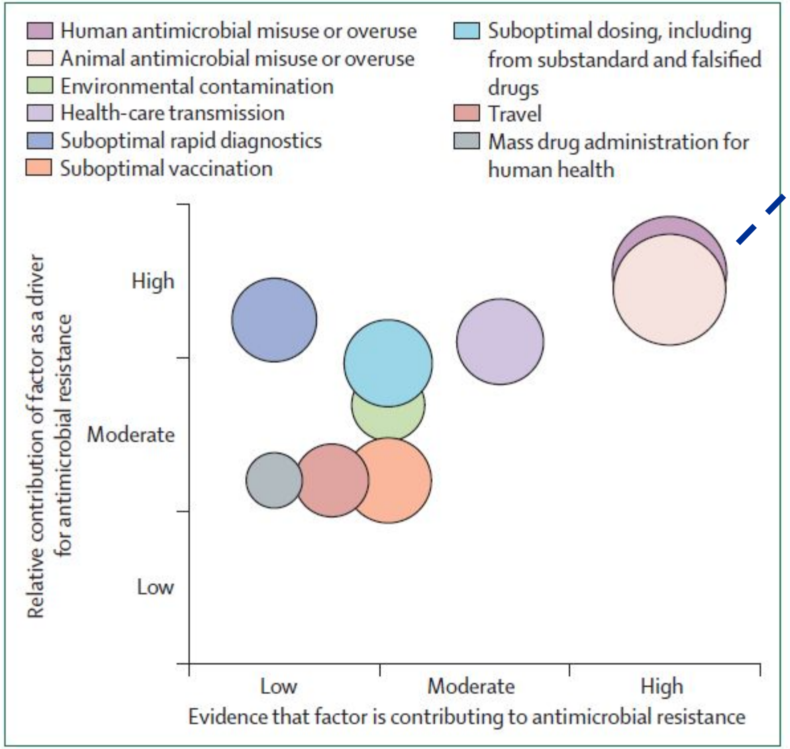
Eastern Mediterranean Region

AMR drivers

8 drivers impacting AMR directly or indirectly:



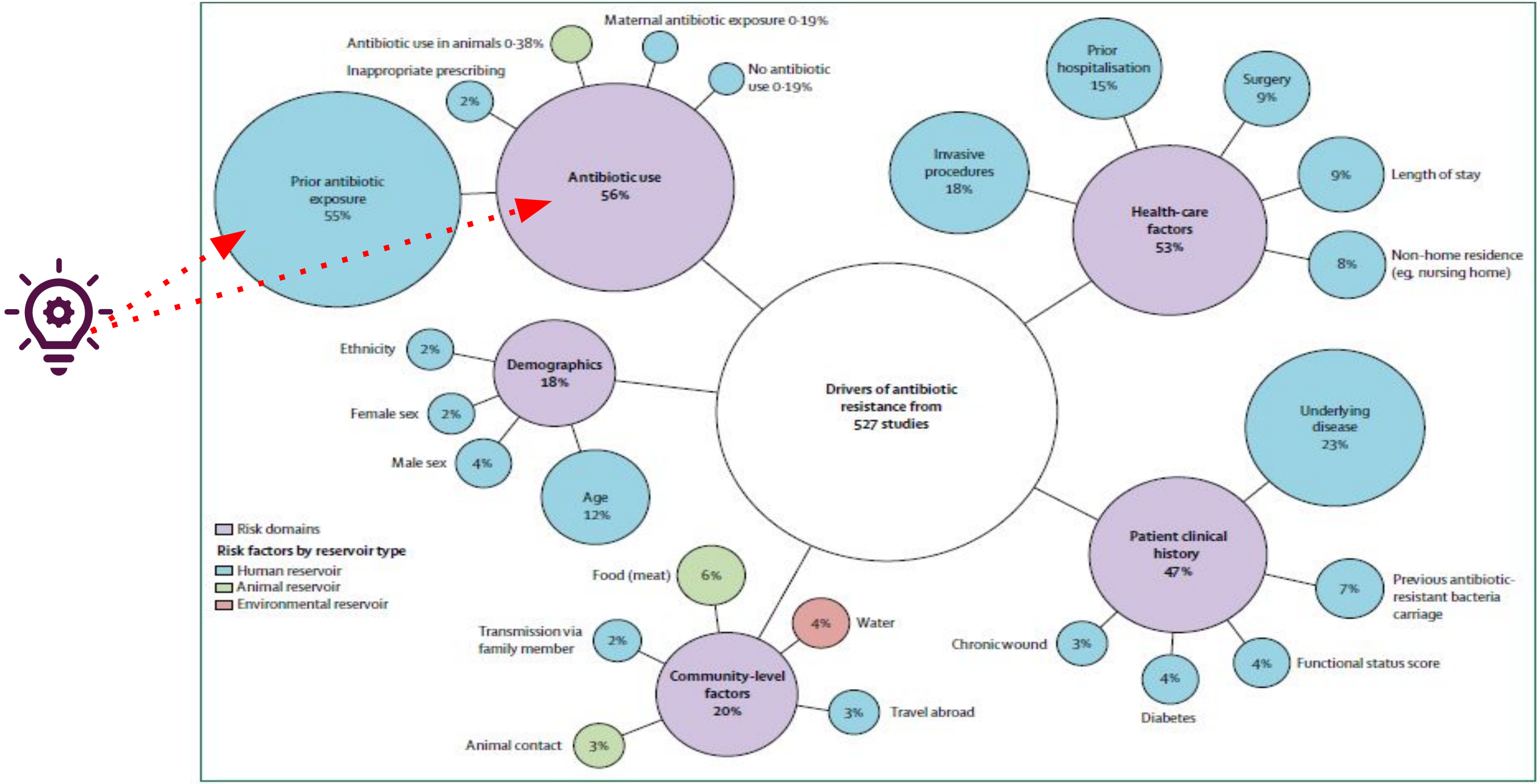
1. **Overuse and misuse of antimicrobials**
2. Poor access to quality medicines, vaccines and diagnostics
3. Poor Infection Prevention and control
4. Lack of clean water, sanitation and hygiene (WASH)
5. Lack of new antibiotics
6. Agricultural practices
7. Globalization and trade
8. Poor public awareness

World Health Organization

Holmes, et al. (2016). Understanding the mechanisms and drivers of antimicrobial resistance. The *La*

Prior antibiotic is the risk factors with the most supporting evidence

- Review of abundance and quality of studies on AMR risk factor for humans
- 5 risk domains and their individual risk factors



- Chatterjee, A et al. Quantifying drivers of antibiotic resistance in humans: a systematic review. *The Lancet Infectious Diseases* (2018)

Antibiotic consumption in humans

World Health Organization

Global increase and geographic convergence in antibiotic consumption between 2000 and 2015

Eili Y. Klein[a,b,c,1], Thomas P. Van Boeckel[d], Elena M. Martinez[a], Suraj Pant[a], Sumanth Gandra[a], Simon A. Levin[e,f,g,1], Herman Goossens[h], and Ramanan Laxminarayan[a,f,i]

PNAS

2000-2015:

- 65% increase in global antibiotic consumption (21 billion to 35 billion DDDs)
- Increase in global antibiotic consumption **driven by LMIC**
    - However, access is still an issue in LMIC where burden of infectious diseases is greater than burden of resistant infections.
    - Rising resistance to affordable first-line treatments increases barriers to access in LMIC

Increase:

cephalosporins 400%, quinolones 125% and macrolides 120%

Source: Klein et al. Global increase and geographic convergence in antibiotic consumption between 2000 and 2015. PNAS latest articles, 2018:1-8

AMR impacts on human health

Health impacts

> High morbidity and mortality rates

> Limited treatment options

> Increased risk of complications

> Reduced efficacy of medical procedures

Healthcare system impacts

> Increased healthcare costs

> Increased risk of transmission

Societal impacts

> Impact on vulnerable populations

> Economic impact

Table 2. Direct and indirect consequences of AMR (antimicrobial resistance).

Direct	Indirect/Inability to Perform:
Decreased efficacy of available antimicrobial drugs	Complex surgical procedures
The onset of administering	Wounds infections
The recovery rate and quality of life (QoL) of affected patients decreases	Hip/knee replacements
	Organ transplant
Healthcare use and length of hospital stay increases	Cancer Chemotherapy
Increased costs for the healthcare infrastructure	Intensive care
Decreased trust in medicine and pharmaceuticals	Care of neonates/preterm babies

https://doi.org/10.3390/ejihpe11010006

Patient and Healthcare excess costs from AMR infections

- Use of second line antibiotics
- Excess length of stay due to resistant infection
- Higher treatment intensity including ICU care

Patient and Healthcare Costs

- ❖ OECD countries: spend between $10,000-$40,000 extra on treating MDR infections *(OECD, 2015)*

- ❖ USA: healthcare costs for adult patients with MRSA were $34 657 compared with $15,923 for patients with MSSA

(Filice et al, ICHE, 2010)

- ❖ Ghana: compared LoS and patient cost in cohort of **patients** with BSI from MRSA or Enterobacterales resistant to 3rd gen Cephalosporins; matched cohorts with sensitive pathogens; cohorts with no infections:
  - Mean extra patient cost was US$1,300 relative to the susceptible patients *(Otieku et al, Pharmacoeconomics open, 2023)*
    - 30% resulted from work productivity loss

Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis

Antimicrobial Resistance Collaborators*

Summary

Background Antimicrobial resistance (AMR) poses a major threat to human health around the world. Previous publications have estimated the effect of AMR on incidence, deaths, hospital length of stay, and health-care costs for specific pathogen–drug combinations in select locations. To our knowledge, this study presents the most comprehensive estimates of AMR burden to date.

Lancet 2022; 399: 629–55

Published Online
January 20, 2022
https://doi.org/10.1016/S0140-6736(21)02724-0

GRAM Study Data Source

Available Data:

Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2019: age-specific and sex-specific estimates of disease burden for 369 diseases and injuries in 204 countries and territories in 1990–2019.

Collected additional data sources (mapping):

The diverse data sought included the following sources:

1. **pharmaceutical companies that run surveillance networks,**
2. **diagnostic laboratories,**
3. **clinical trial data;**
4. **high-quality data from researchers**: (large multisite research collaborations, smaller studies, clinical trials, and well-established research institutes in LMICs)
5. **Public and private hospitals and public health institutes that provide diagnostic testing**
6. **Surveillance data:** (global surveillance networks; enhanced surveillance systems; national surveillance systems; surveillance systems for specific organisms such as *Mycobacterium tuberculosis* and *Neisseria gonorrhoeae)*

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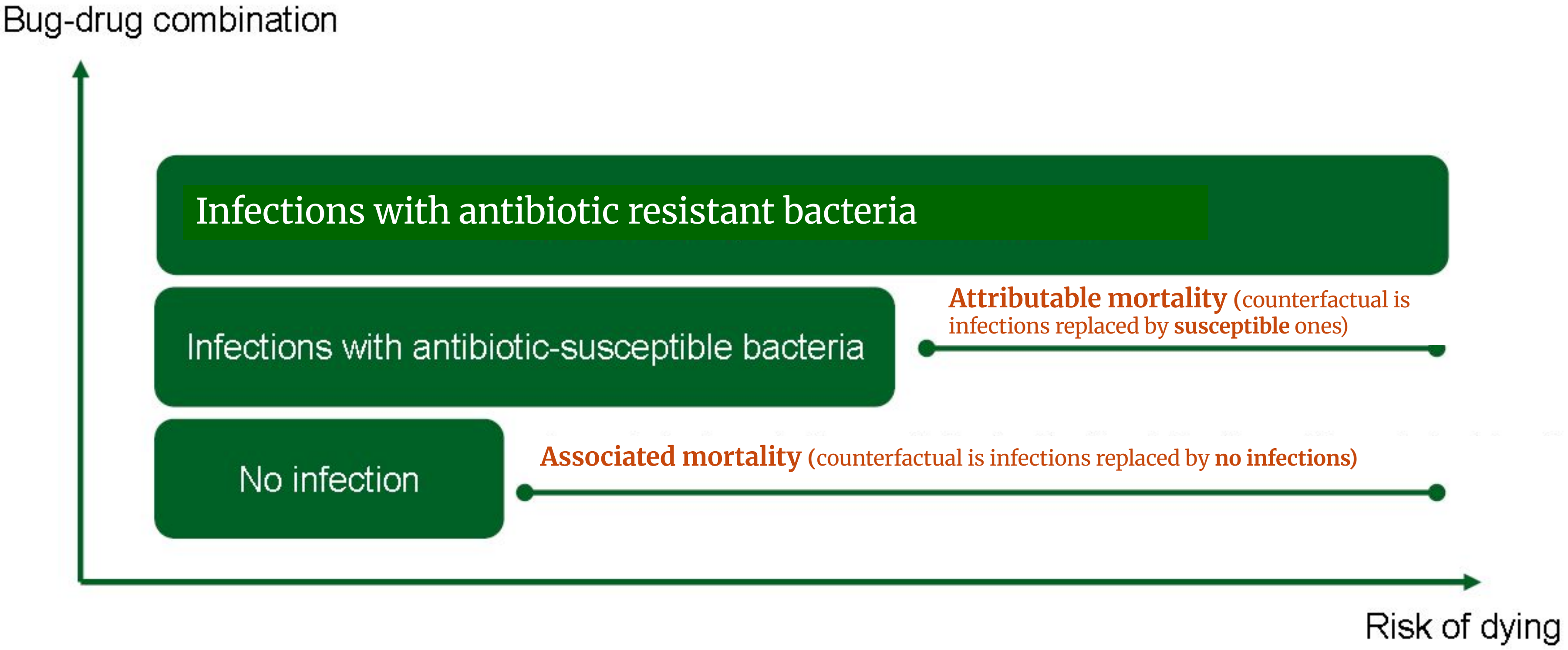
Associated vs attributable mortality



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AMR Estimation

1. Estimate absolute number of infectious deaths (sepsis)
2. Estimate proportion of sepsis due to different infectious syndromes
3. Estimate distribution of pathogens within each infectious syndrome
4. For various bacterial pathogens estimate the proportion of infections resistant to antibiotics of clinical importance
5. For infections that are resistant, estimate the increased risk of death associated with that resistance (relative risk)

Definitions

- Sepsis – A life-threatening disease in which a dysregulated host response to an **infection** leads to **organ dysfunction**

- Infectious syndromes – Infectious underlying causes of death or the **infection responsible for sepsis** in the cause of death chain; the bridge between underlying causes and sepsis

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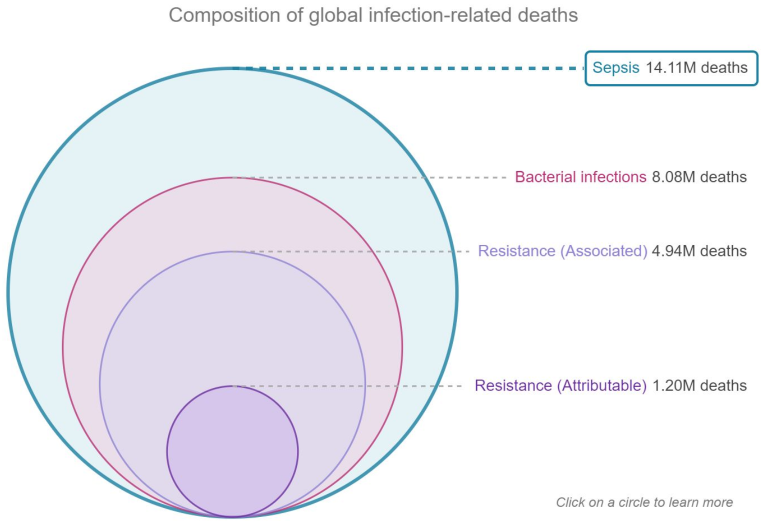
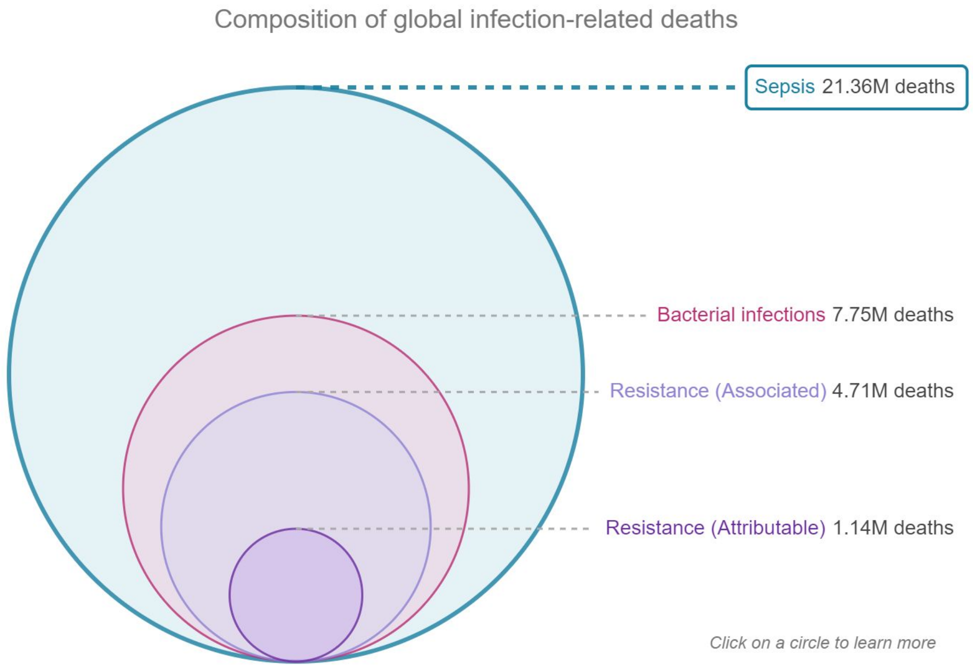
Sepsis, Bacterial Infection, Associated AMR, Attributable AMR 2019 and 2021





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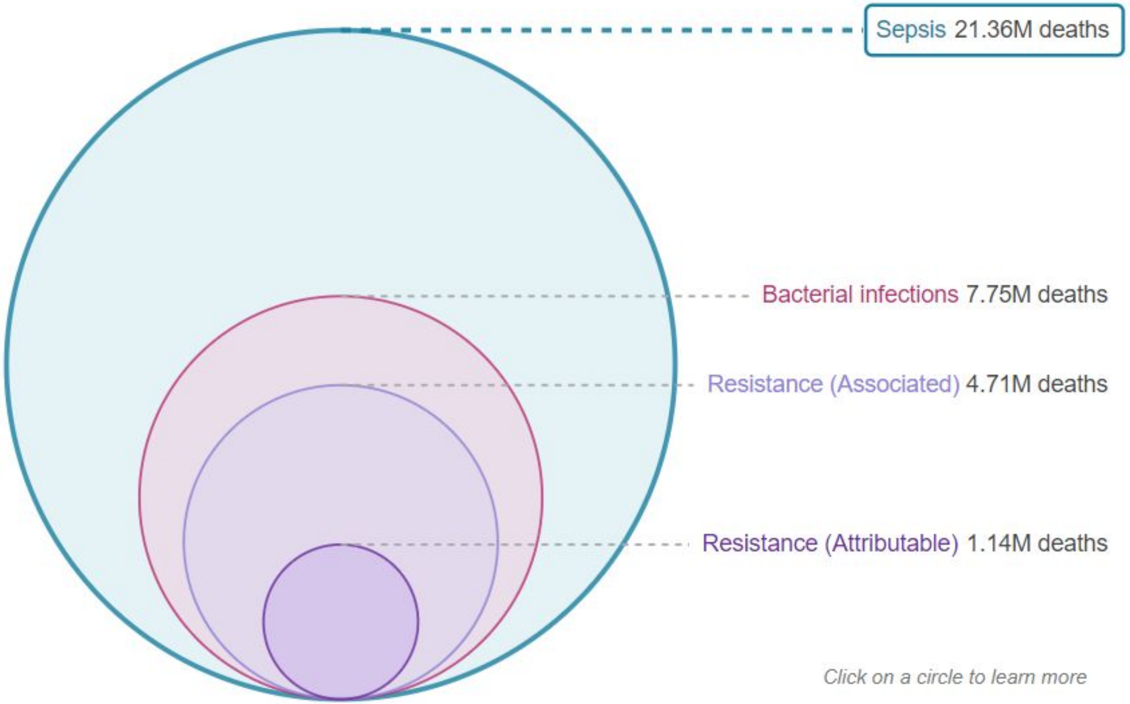
AMR exists within a greater universe of infection

Composition of global infection-related deaths



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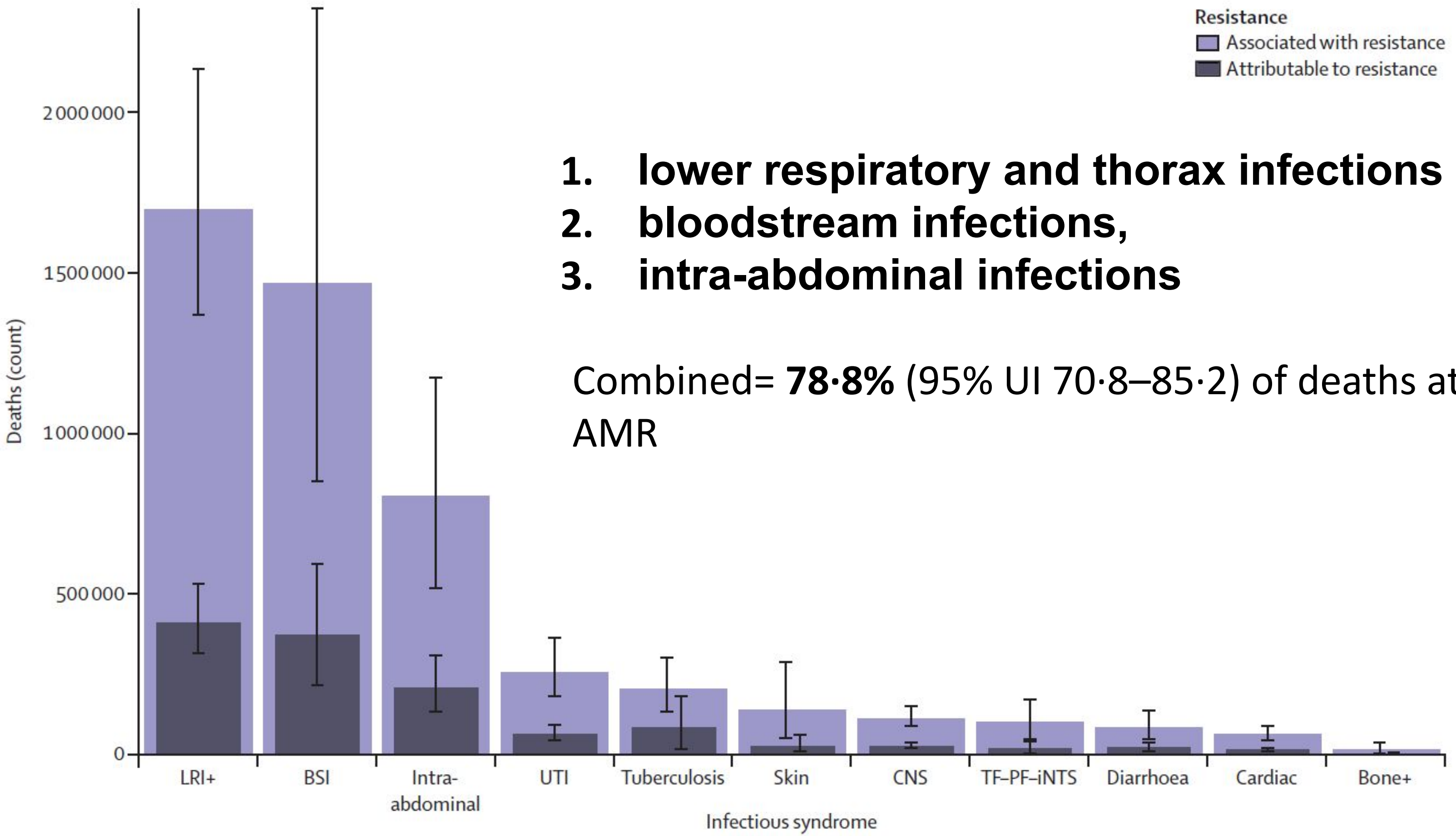
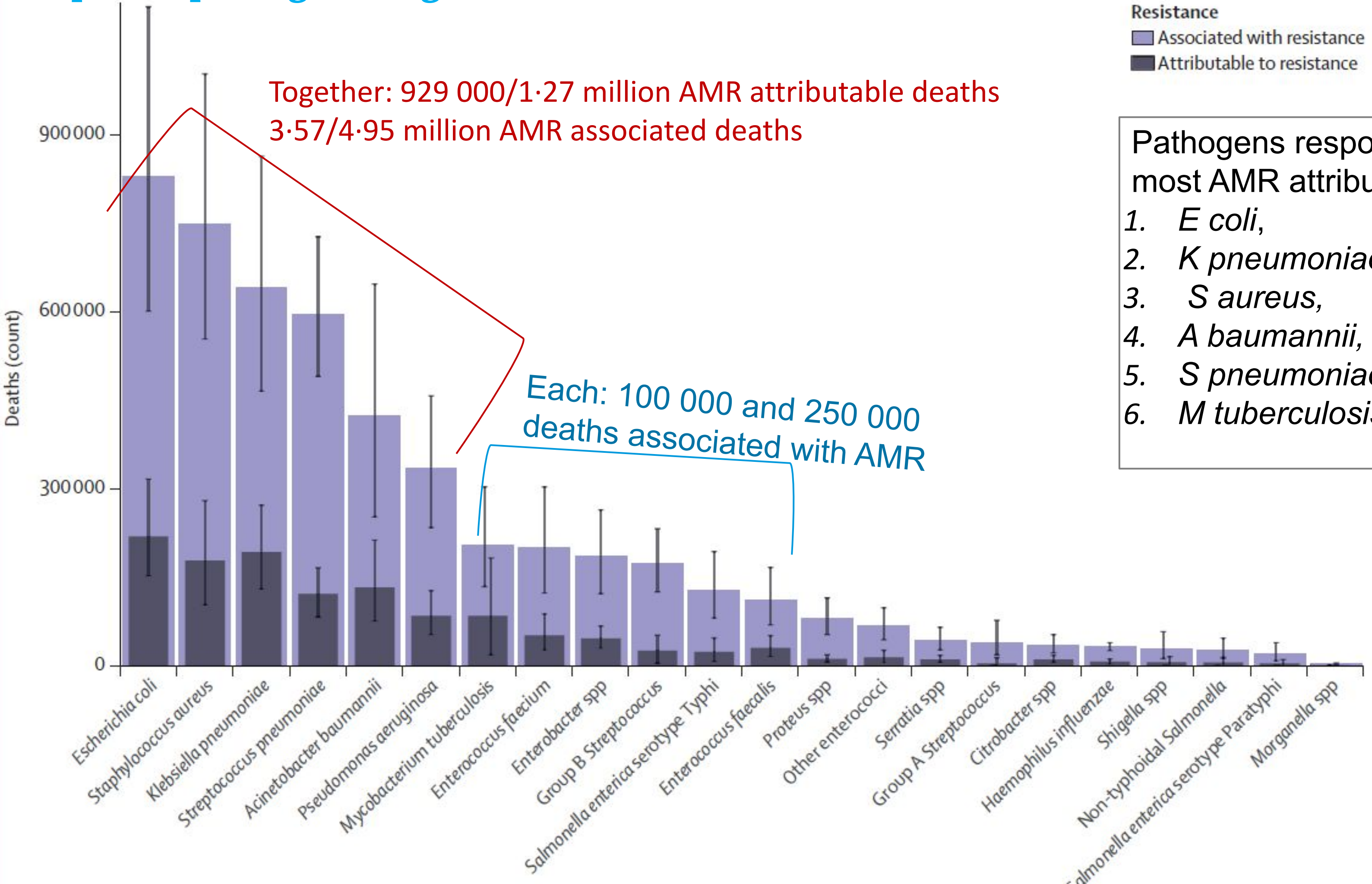
Top infection syndromes in GBD attributable to/associated with AMR in 2019



1. **lower respiratory and thorax infections (400K)**
2. **bloodstream infections,**
3. **intra-abdominal infections**

Combined= **78·8%** (95% UI 70·8–85·2) of deaths attributable to AMR

Top 6 six pathogens in global burdens attributable and associated with AMR in 2019:



Pathogens responsible for the most AMR attributable deaths:

1. *E coli*,
2. *K pneumoniae*,
3. *S aureus*,
4. *A baumannii*,
5. *S pneumoniae*,
6. *M tuberculosis*.

AMR burden caused by each of the six leading pathogens differed substantially across GBD super-regions.

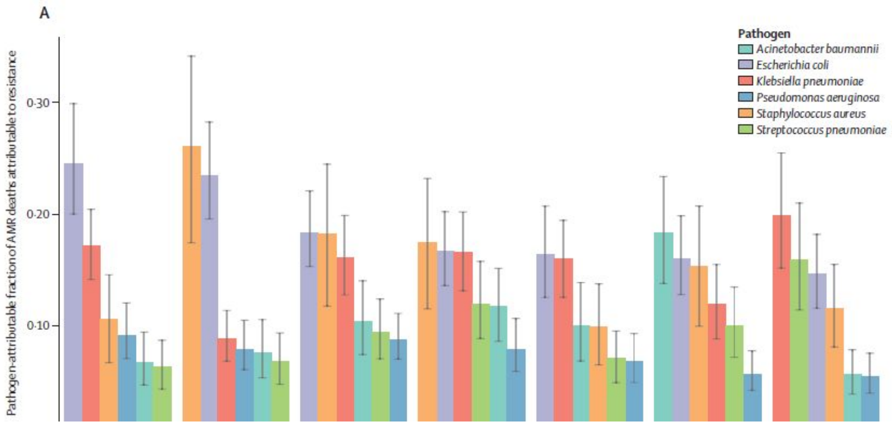
In the high-income region: approx 50% of fatal AMR burden was linked to two pathogens:

- ***S aureus*** (26·1% (attributable) & 25.4% (associated));
- ***E coli*** (23.4% & 24.3%)

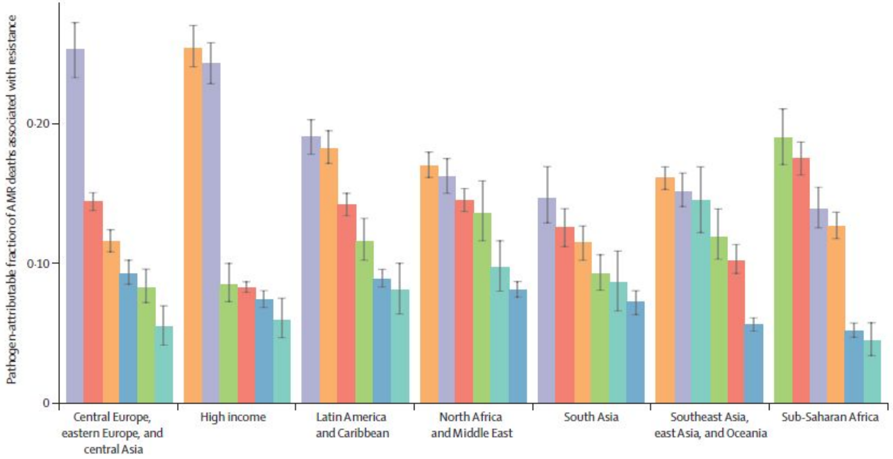
In sub-Saharan Africa region: fatal AMR burden linked to:

- ***S pneumoniae** (15.9% & 19%)*
- ***K pneumoniae*** (19·9% & 17.5%)

(A) Pathogen-attributable fraction of deaths attributable to resistance across the 6 leading pathogens



(B) Pathogen-associated fraction of deaths attributable to resistance across the 6 leading pathogens



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Around 380,000 sepsis deaths in 2021 in the Region were associated with bacterial AMR

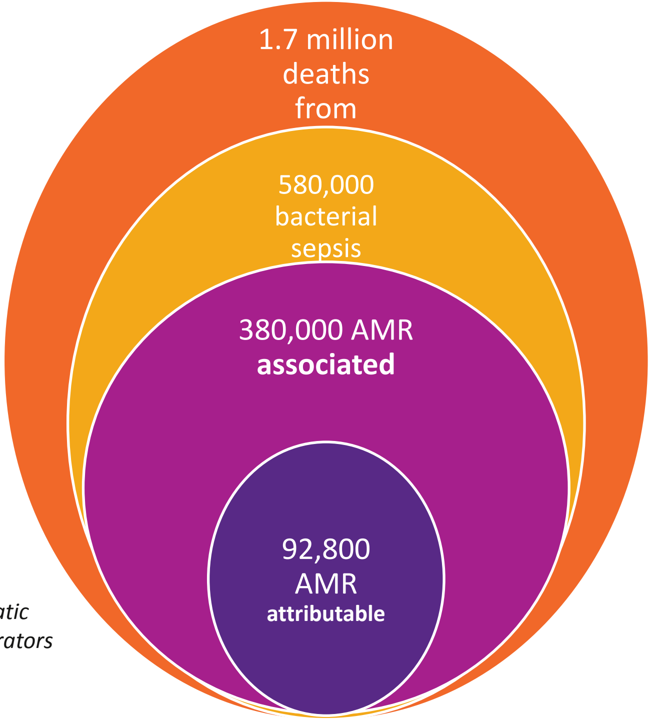
The burden of bacterial antimicrobial resistance in the WHO Eastern Mediterranean Region 1990–2021: a cross-country systematic analysis with forecasts to 2050

*EMR Antimicrobial Resistance Collaborators**

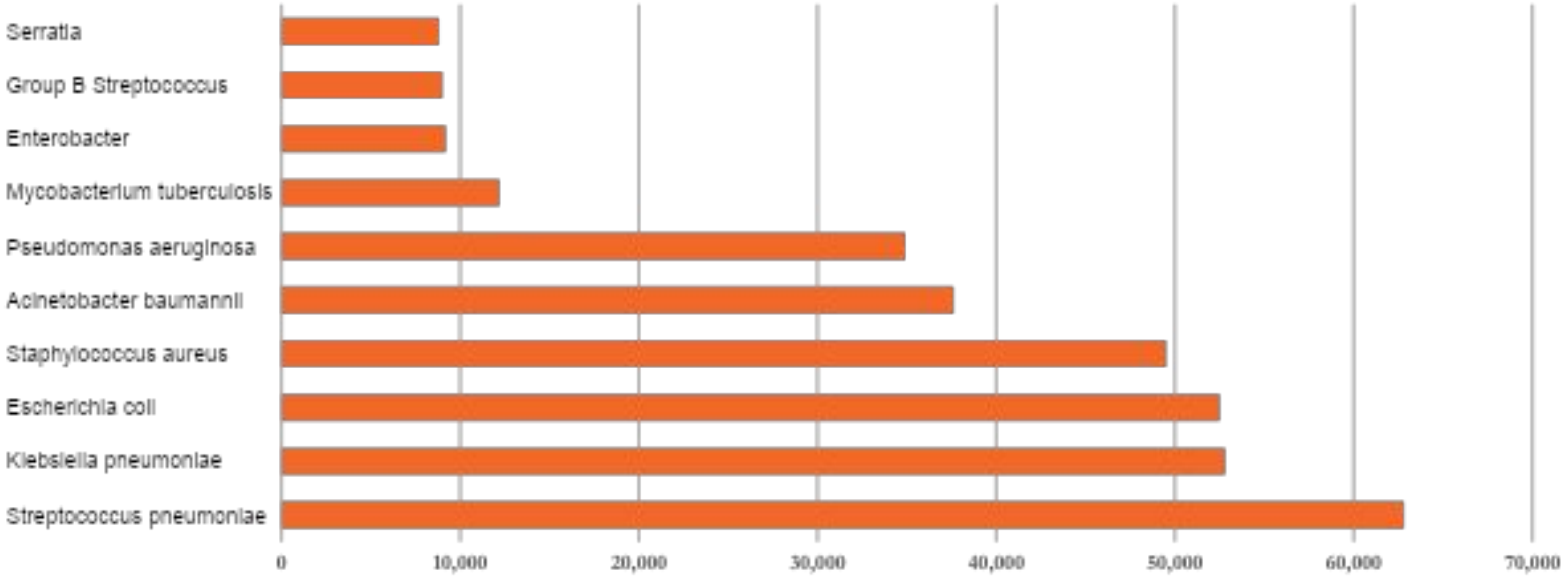
GBD

oa

Global burden of bacterial antimicrobial resistance 1990–2021: a systematic analysis with forecasts to 2050. GBD 2021 Antimicrobial Resistance Collaborators



Top ten pathogens contributing to AMR associated mortality in EMR, 2021 (GRAM)



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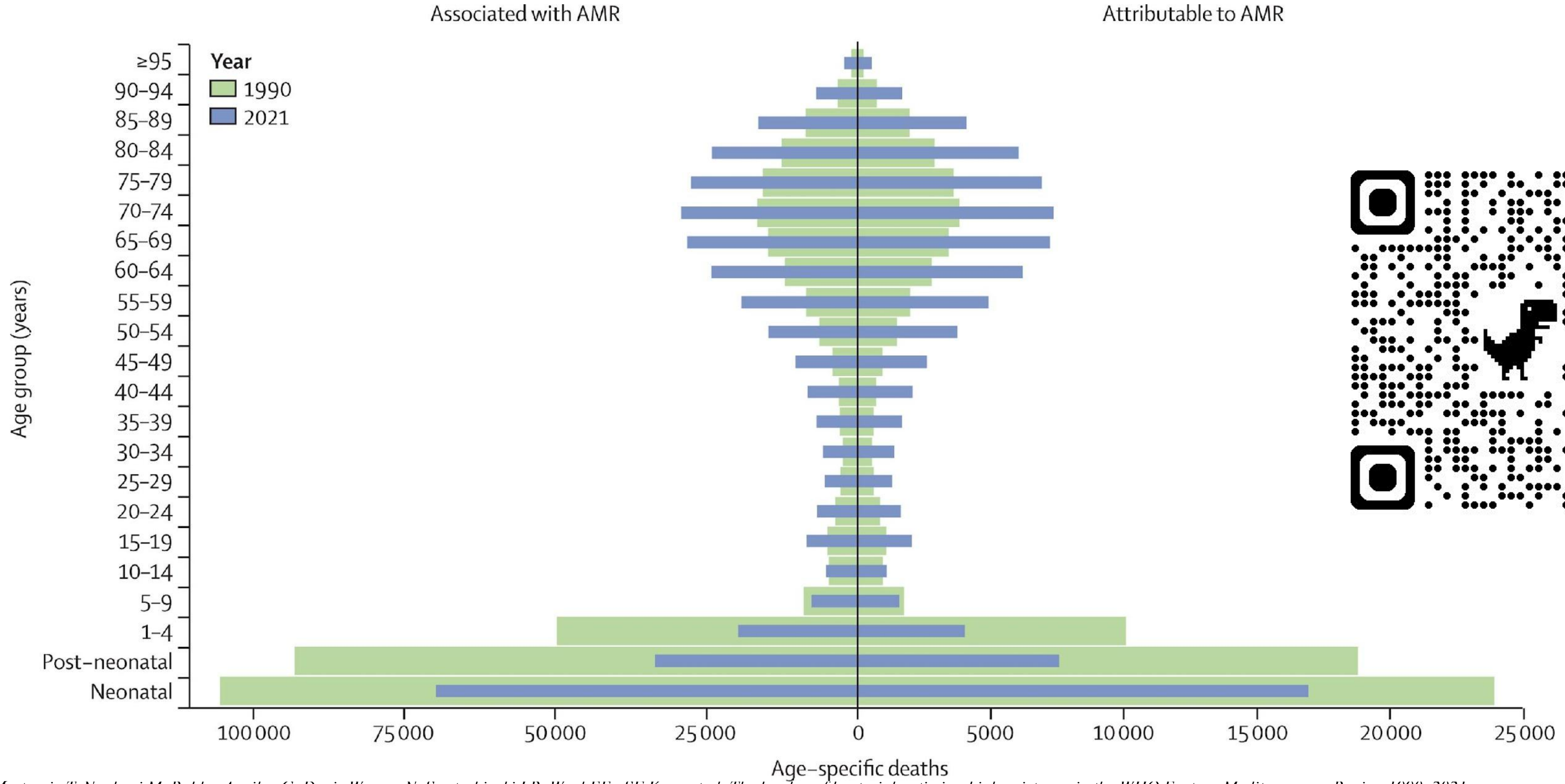
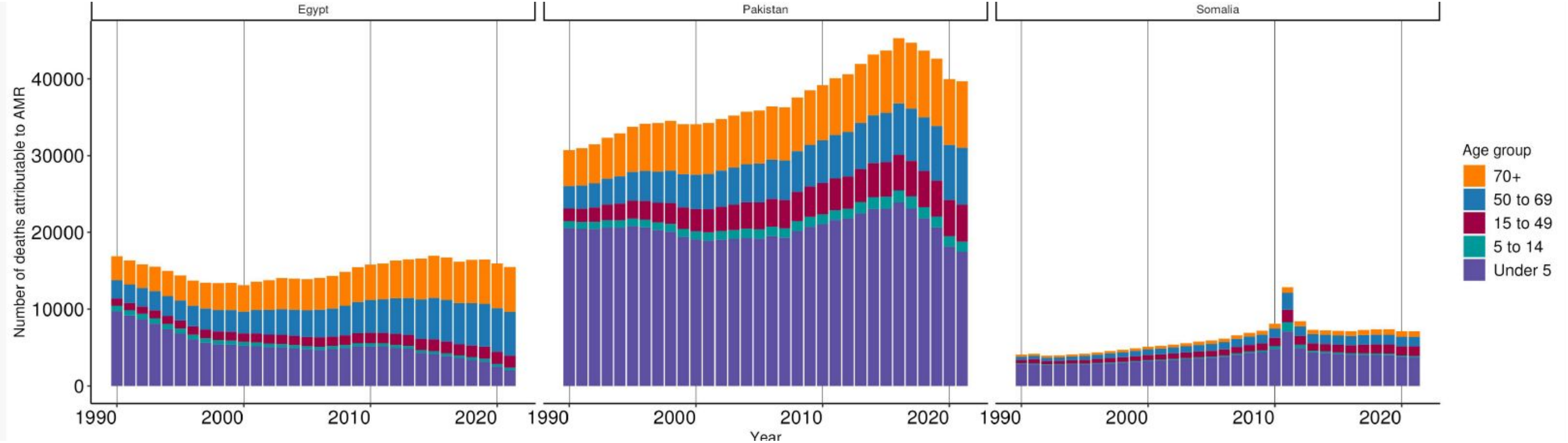
Regional burden of bacterial antimicrobial resistance 1990–2021: a systematic analysis with forecasts to 2050. GBD 2021 Antimicrobial Resistance Collaborators. https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(24)01867-1/fulltext

Age-specific mortality for deaths attributable to and deaths associated with AMR in the WHO Eastern Mediterranean Region in 1990 and 2021



Mestrovic T, Naghavi M, Robles Aguilar G, Davis Weaver N, Swetschinski LR, Wool EE, ,SF Koya et al. The burden of bacterial antimicrobial resistance in the WHO Eastern Mediterranean Region 1990–2021: a cross-country systematic analysis with forecasts to 2050. The Lancet Public Health [Internet]. 2025 Oct [cited 2025 Oct 25]; Available from: https://www.thelancet.com/journals/lanpub/article/PIIS2468-2667(25)00201-4/fulltext

Number of deaths attributable to AMR across age groups: top three countries in EMR



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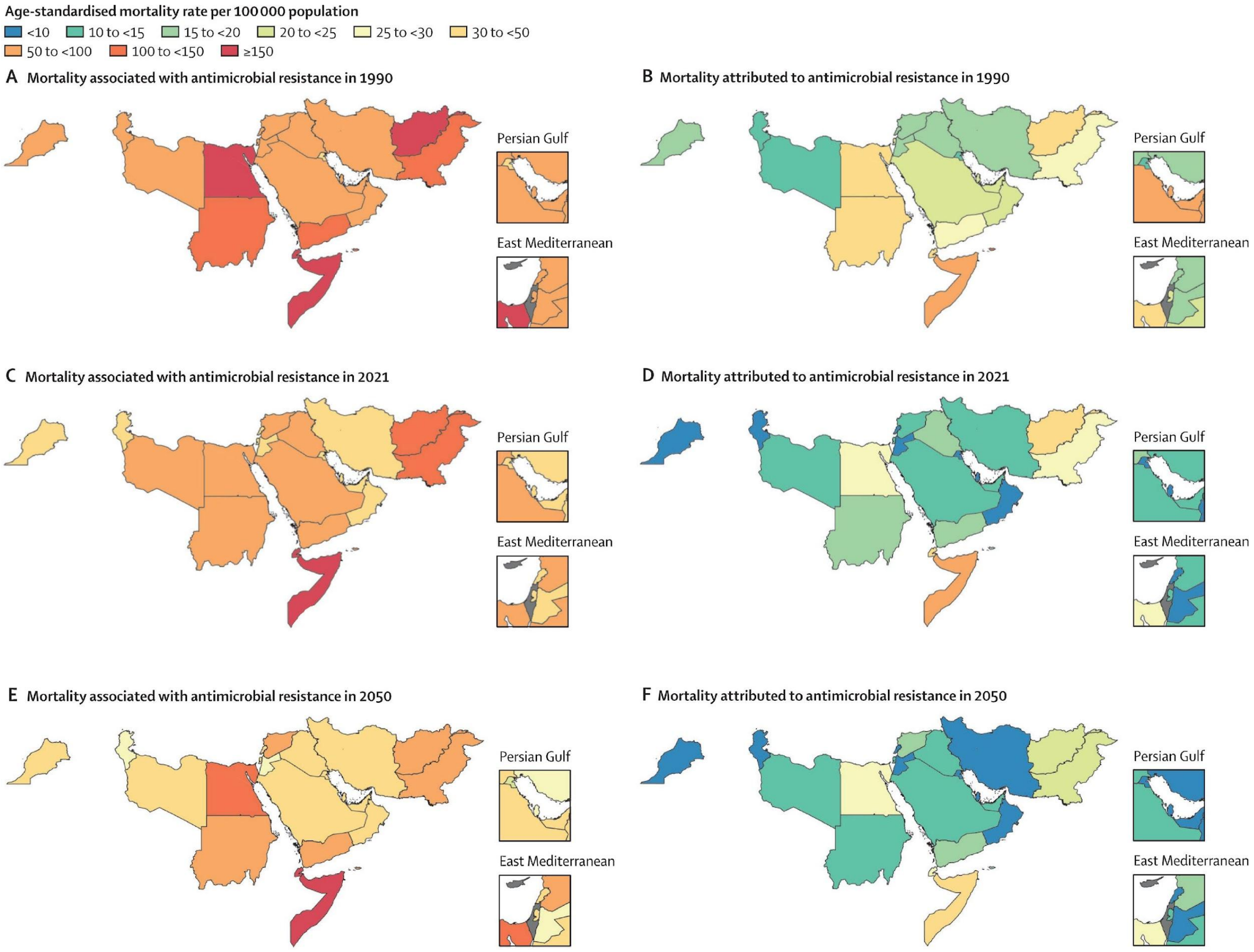
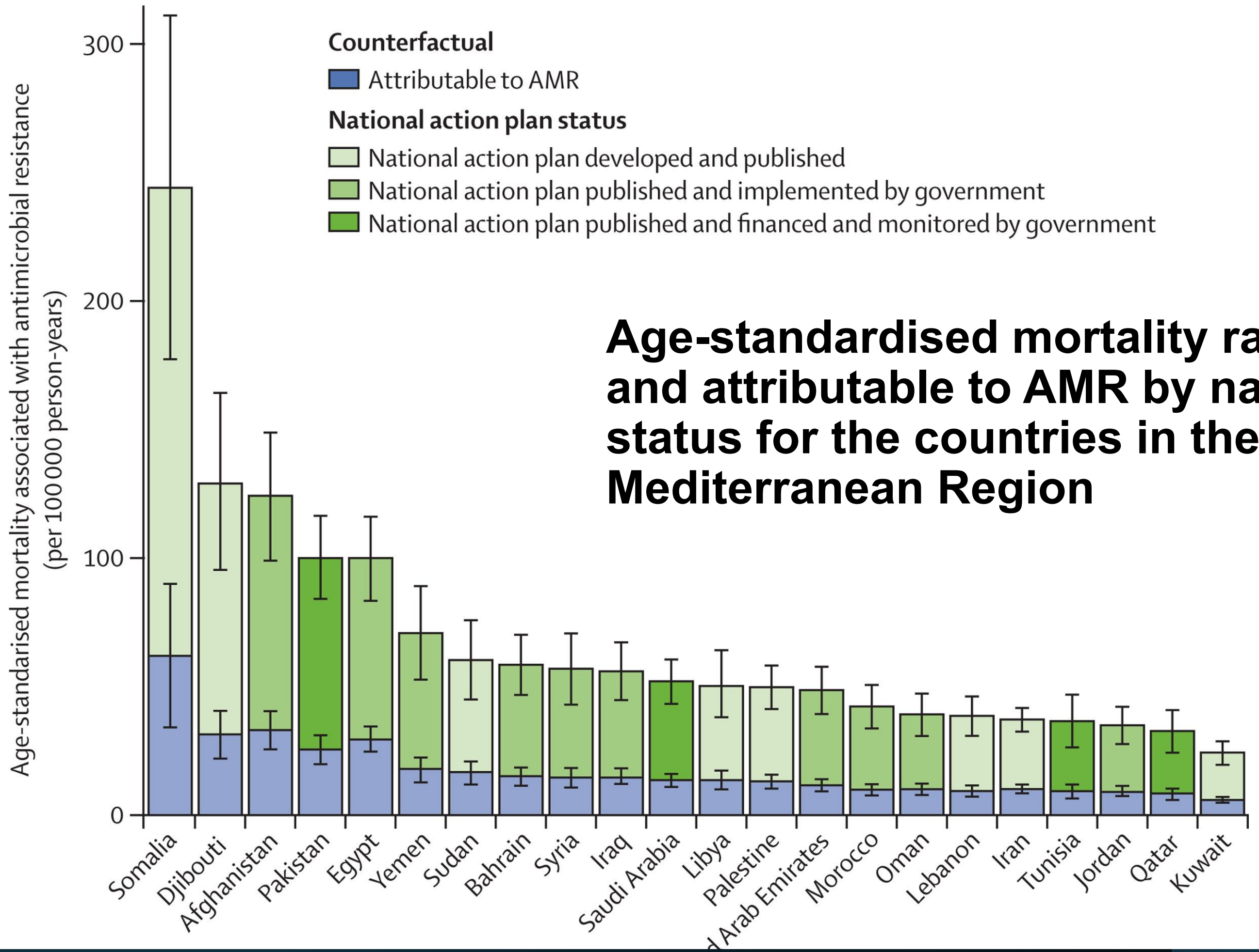
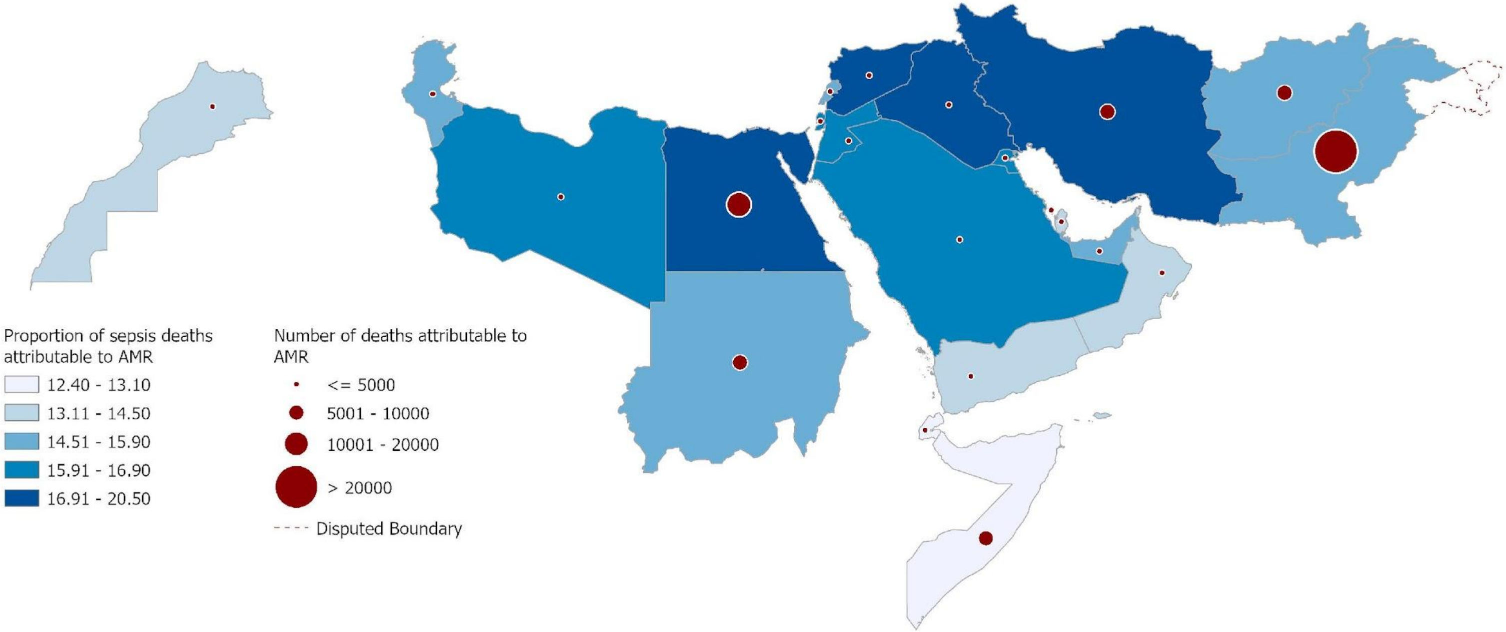
Age-standardised mortality rates per 100 000 population for deaths associated with and attributable to antimicrobial resistance in the WHO Eastern Mediterranean Region in 1990 (A, B), 2021 (C, D) and 2050 (E, F)



Age-standardised mortality rate associated with and attributable to AMR by national action plan status for the countries in the WHO Eastern Mediterranean Region



Deaths attributable to AMR, 2019 (GRAM data)



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Global antibiotic consumption and usage in humans, 2000–18: a spatial modelling study

Annie J Browne, Michael G Chipeta, Georgina Haines-Woodhouse, Emmanuelle P A Kumaran, Bahar H Kashef Hamadani, Sabra Zaraa, Nathaniel J Henry, Aniruddha Deshpande, Robert C Reiner Jr, Nicholas P J Day, Alan D Lopez, Susanna Dunachie, Catrin E Moore, Andy Stergachis, Simon I Hay, Christiane Dolecek

10.1016/S2542-5196(21)00280-1

Lancet Planetary Health
2021

Estimated a global antibiotic consumption rate of 14·3 (95% uncertainty interval 13·2–15·6) defined daily doses (DDD) per 1000 population per day in 2018 (40·2 [37·2–43·7] billion DDD), an increase of 46% from 9·8 (9·2–10·5) DDD per 1000 per day in 2000.

High rates of antibiotic consumption, spatial disparities, and a lack of access to antibiotics.

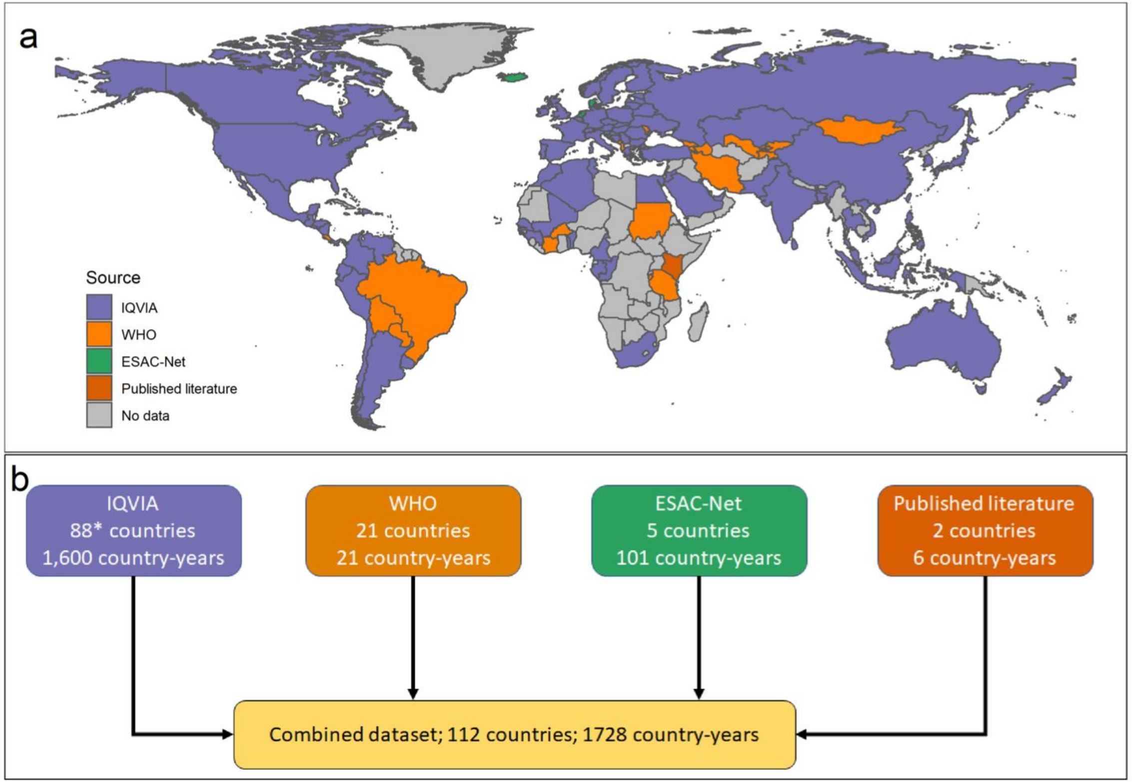

Figure 4.2: Antibiotic consumption data availability. a) A map of countries with data available by source; b) A flow chart of the number of countries and country-years from each data source and overall. *IQVIA is stated to cover 88 countries here as the Central America and French West Africa regions have been disaggregated into their individual countries.

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Eastern Mediterranean Region

source: Annie Browne DPhil thesis, University of Oxford

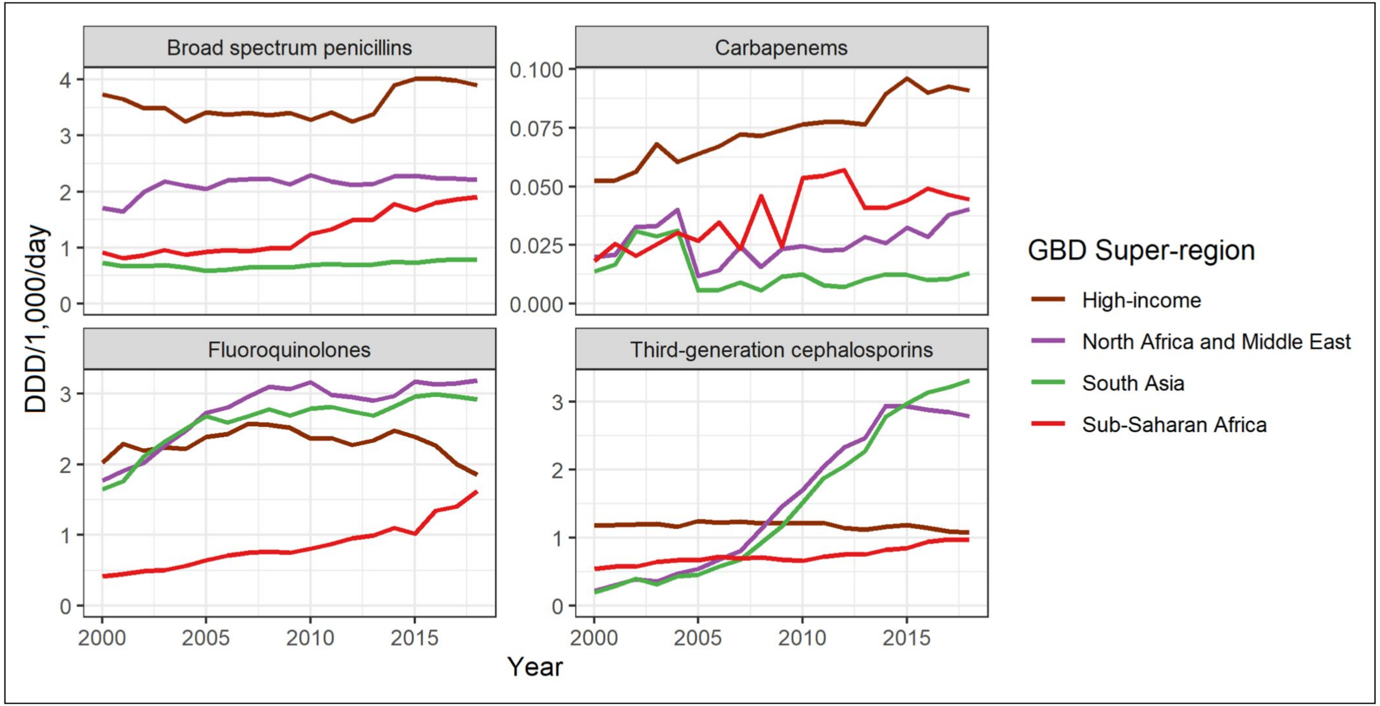

Figure 4.8: Temporal trends in consumption of selected ATC level 4 antibiotic classes, displayed for four selected GBD super-regions. The proportion of each antibiotic class (ATC level 4) was calculated from the IQVIA dataset and applied to the modelled

Browne et al, Lancet Planet Health 2021; 5: e893–904 https://doi.org/10.1016/S2542-5196(21)00280-1

GRAM
Global Research on Antimicrobial Resistance

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/ GRAM Research / Antibiotic usage and consumption

Antibiotic usage and consumption

Data visualisations | Maps | Plots | Model estimates

Indicator:

Total antibiotic consumption

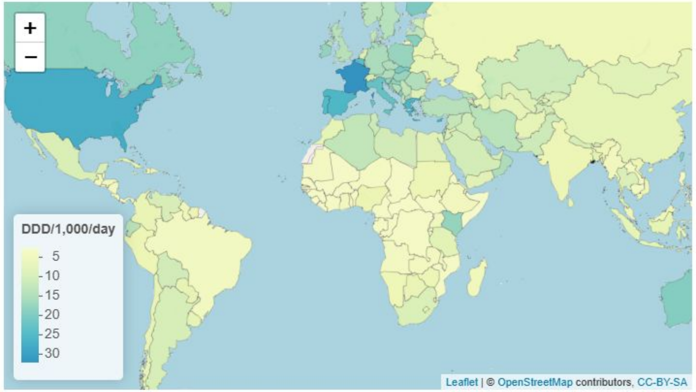
Year

2000 2018

2000 2002 2004 2006 2008 2010 2012 2014 2016 2018

The maps displayed here present the results from Browne AJ et al 2021 Global antibiotic consumption and usage in humans, 2000 to 2018: a spatial modelling study

Total antibiotic consumption displays maps of the rate of total antibiotic consumption in each country, expressed as defined daily doses per 1,000 population per day (DDD/1,000/day). Hovering over the relevant country will display the modelled estimates of antibiotic consumption with the accompanying uncertainty intervals. Using the slider will display the estimated rates of antibiotic consumption for each year, from 2000 to 2018.



If you use these modelled estimates on antibiotic consumption and antibiotic usage, please cite this publication as a reference: Browne AJ, Chipeta MG, Haines-Woodhouse G, et al. Global antibiotic consumption and usage in humans, 2000 to 2018: a spatial modelling study. Lancet Planetary Health 2021

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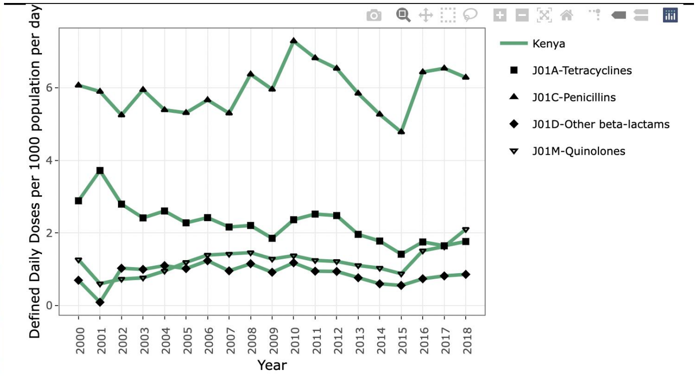


World Health Organization
Eastern Mediterranean Region

https://www.tropicalmedicine.ox.ac.uk/gram/research/visualisation-app-antibiotic-usage-and-consumption

World Health Organization

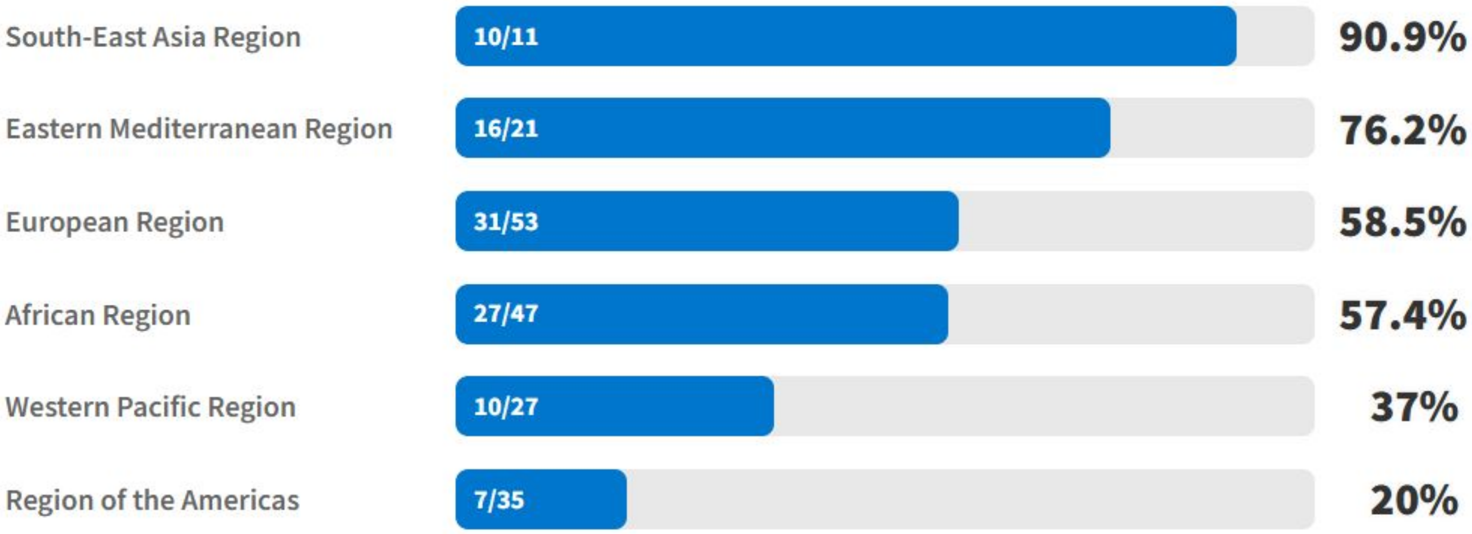
Global antibiotic resistance surveillance report 2025

- Global analysis of antibiotic resistance prevalence and trends
- Drawing on more than 23 million bacteriologically confirmed cases of bloodstream infections, urinary tract infections, gastrointestinal infections, and urogenital gonorrhoea.
- Data were reported by 104 countries in 2023

Global Antimicrobial Resistance and Use Surveillance System (GLASS)

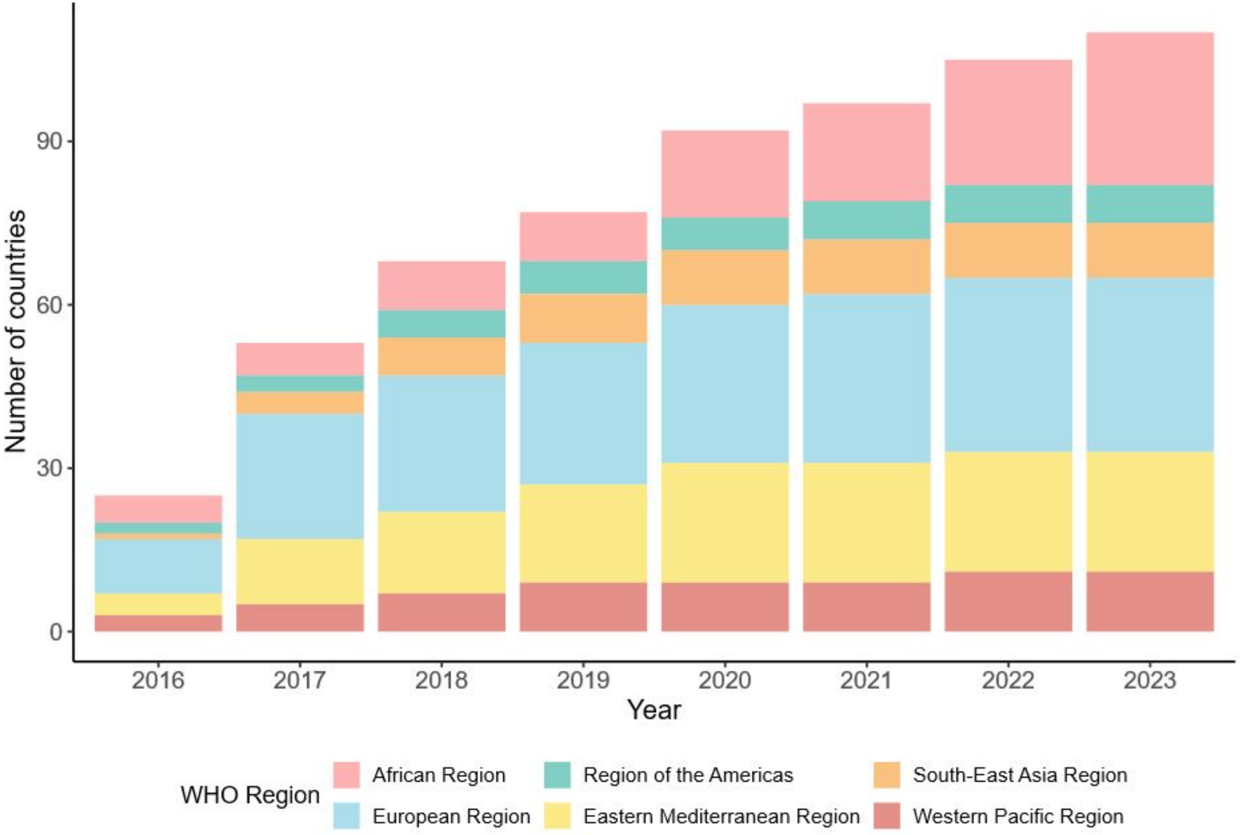
WHO Regions Reporting AMR Data to GLASS

Reporting progress: Percentage of Member States reporting / Total Member States



World Health Organization

Countries reporting data to WHO's GLASS (2016-2023)



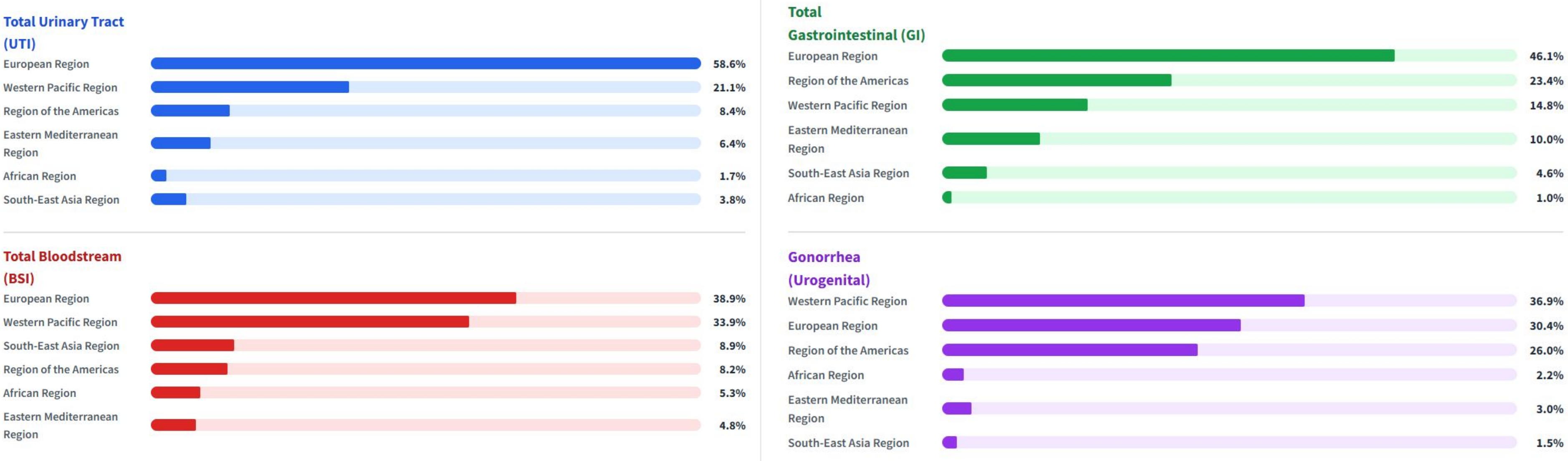
World Health Organization

A country is considered to have reported AMR data if it has submitted AST results for at least one surveillance-defined infection type, pathogen and antibiotic combination under surveillance for at least one calendar year.

GLASS Enrollment and AMR Data Reporting by WHO Region (2016–2023, 2023)

Legal status	Number	Enrolled in GLASS (% (n))	Reported AMR data to GLASS (% (n)) 2016–2023	2023
Member states	194	65.5 (127)	55.2 (107)	52.1 (101)
African Region	47	93.6 (44)	59.6 (28)	57.4 (27)
Region of the Americas	35	22.9 (8)	20.0 (7)	20.0 (7)
South-East Asia Region	11	100.0 (11)	90.9 (10)	90.9 (10)
European Region	53	60.4 (32)	58.5 (31)	58.5 (31)
Eastern Mediterranean Region	21	100.0 (21)	100.0 (21)	76.2 (16)
Western Pacific Region	27	40.7 (11)	37.0 (10)	37.0 (10)
Associate members	2	–	–	–
Region of the Americas	1	–	–	–
Western Pacific Region	1	–	–	–
Territories or areas	20	15.0 (3)	15.0 (3)	15.0 (3)
Region of the Americas	9	–	–	–
European Region	2	50.0 (1)	50.0 (1)	50.0 (1)
Eastern Mediterranean Region	1	100.0 (1)	100.0 (1)	100.0 (1)
Western Pacific Region	8	12.5 (1)	12.5 (1)	12.5 (1)
Total	216	60.2 (130)	50.9 (110)	48.1 (104)
African Region	47	93.6 (44)	59.6 (28)	57.4 (27)
Region of the Americas	45	17.8 (8)	15.6 (7)	15.6 (7)
South-East Asia Region	11	100.0 (11)	90.9 (10)	90.9 (10)
European Region	55	60.0 (33)	58.2 (32)	58.2 (32)
Eastern Mediterranean Region	22	100.0 (22)	100.0 (22)	77.3 (17)
Western Pacific Region	36	33.3 (12)	30.6 (11)	30.6 (11)

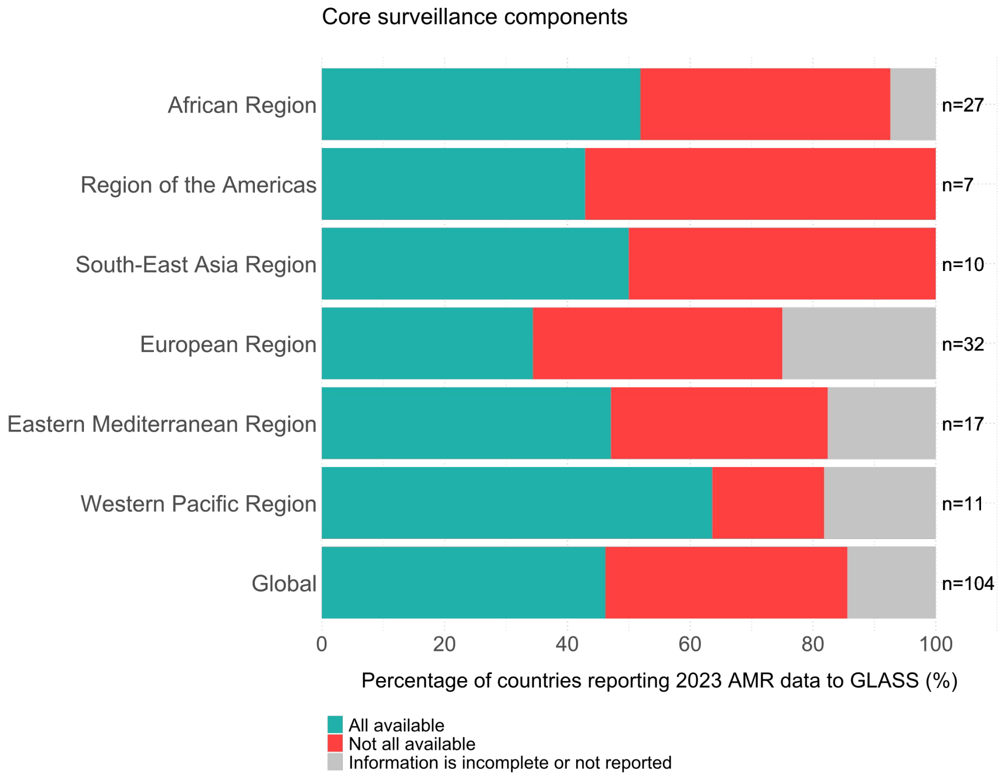
Total infections bacteriologically confirmed with AST results reported to WHO GLASS by infection site and WHO region (2023)



Total infections bacteriologically confirmed with AST results reported to WHO GLASS by infection type, pathogen, and WHO region (2016-2023; 2023)

	No. of infections with AST (no. of countries)[a]													
	Global		African Region		Region of the Americas		South-East Asia Region		European Region		Eastern Mediterranean Region		Western Pacific Region	
	2016-2023	2023	2016-2023	2023	2016-2023	2023	2016-2023	2023	2016-2023	2023	2016-2023	2023	2016-2023	2023
Total bloodstream	4 217 990 (106)	683 269 (99)	175 782 (24)	36 314 (23)	175 321 (7)	55 908 (6)	234 985 (10)	60 908 (10)	1 991 588 (32)	265 625 (32)	149 564 (22)	32 622 (17)	1 490 750 (11)	231 892 (11)
Acinetobacter spp.	216 201 (104)	49 409 (95)	31 412 (23)	7437 (23)	9695 (6)	2482 (4)	47 202 (10)	14 828 (10)	64 559 (32)	11 737 (31)	22 511 (22)	5595 (16)	40 822 (11)	7330 (11)
E. coli	2 070 346 (104)	306 783 (96)	33 168 (24)	6727 (22)	57 056 (6)	18 658 (6)	65 226 (10)	17 405 (10)	1 066 845 (32)	128 607 (31)	41 839 (21)	9847 (16)	806 212 (11)	125 539 (11)
K. pneumoniae	781 202 (105)	144 298 (97)	49 280 (24)	10 048 (23)	43 835 (6)	13 643 (6)	56 245 (10)	14 672 (10)	294 796 (32)	47 905 (31)	36 678 (22)	8650 (16)	300 368 (11)	49 380 (11)
Salmonella spp.	65 344 (95)	9375 (84)	7935 (22)	1714 (19)	9410 (6)	2140 (5)	11 593 (10)	896 (10)	5693 (28)	1850 (26)	17 001 (18)	596 (14)	13 712 (11)	2179 (10)
S. aureus	945 780 (104)	149 942 (96)	48 886 (23)	9827 (23)	46 633 (6)	14 499 (5)	53 473 (10)	12 710 (10)	466 990 (32)	61 781 (30)	28 308 (22)	6963 (17)	301 490 (11)	44 162 (11)
S. pneumoniae	139 117 (94)	23 462 (85)	5101 (20)	561 (15)	8692 (5)	4486 (4)	1246 (9)	397 (9)	92 705 (32)	13 745 (32)	3227 (17)	971 (14)	28 146 (11)	3302 (11)
Total gastrointestinal	168 212 (83)	39 579 (75)	9012 (16)	382 (15)	48 804 (6)	9280 (5)	5443 (10)	1817 (10)	60 099 (23)	18 263 (20)	16 292 (19)	3974 (16)	28 562 (9)	5863 (9)
Salmonella spp.	136 456 (83)	33 054 (74)	4590 (16)	214 (15)	30 531 (6)	6506 (5)	5012 (10)	1573 (10)	54 918 (23)	15 799 (20)	14 225 (19)	3418 (16)	27 180 (9)	5544 (8)
Shigella spp.	31 756 (68)	6525 (57)	4422 (13)	168 (11)	18 273 (5)	2774 (4)	431 (8)	244 (7)	5181 (17)	2464 (14)	2067 (17)	556 (14)	1382 (8)	319 (7)
Total urinary tract	19 361 029 (79)	3 761 957 (72)	146 621 (21)	63 480 (21)	1 066 798 (6)	315 354 (6)	478 345 (10)	142 905 (10)	12 198 316 (11)	2 205 725 (9)	866 864 (22)	239 747 (17)	4 604 085 (9)	794 746 (9)
E. coli	16 899 236 (79)	3 216 393 (72)	116 180 (21)	50 650 (21)	927 634 (6)	266 565 (6)	374 803 (10)	111 812 (10)	11 000 331 (11)	1 953 889 (9)	688 425 (22)	188 751 (17)	3 791 863 (9)	644 726 (9)
K. pneumoniae	2 461 793 (76)	545 564 (69)	30 441 (19)	12 830 (19)	139 164 (6)	48 789 (6)	103 542 (10)	31 093 (10)	1 197 985 (11)	251 836 (9)	178 439 (21)	50 996 (16)	812 222 (9)	150 020 (9)
Total urogenital[b]	118 474 (69)	21 208 (52)	6077 (13)	474 (6)	44 494 (5)	5517 (3)	1051 (6)	314 (5)	20 073 (25)	6441 (19)	2773 (12)	628 (12)	44 006 (8)	7834 (7)
Grand total	23 865 705 (110)	4 506 013 (104)	337 492 (28)	100 650 (27)	1 335 417 (7)	386 059 (7)	719 824 (10)	205 944 (10)	14 270 076 (32)	2 496 054 (32)	1 035 493 (22)	276 971 (17)	6 167 403 (11)	1 040 335 (11)

Global and regional implementation of the five core components of national AMR surveillance systems, 2023



Global and regional composite scores for completeness of AMR surveillance data reported to WHO GLASS, 2023

		Global	African Region	Region of the Americas	South-East Asia Region	European Region	Eastern Mediterranean Region	Western Pacific Region
Domain 1	National AMR surveillance system: Core components	83.7	92.6	85.7	85.0	75.0	79.4	90.9
Domain 2	National surveillance coverage	33.1	44.4	14.3	39.2	24.2	39.7	27.3
	National health infrastructure and service utilization	35.1	46.3	19.0	40.0	27.1	40.2	28.8
	Total health facilities	61.5	77.8	28.6	80.0	46.9	76.5	45.5
	Inpatient admissions and days of care per calendar year	6.3	9.3	0.0	10.0	6.3	2.9	4.5
	Outpatient consultations per calendar year	37.5	51.9	28.6	30.0	28.1	41.2	36.4
	Health infrastructure and utilization in facilities reporting to GLASS	31.1	42.6	9.5	38.3	21.4	39.2	25.8
	Total health facilities	59.1	72.2	28.6	80.0	43.8	76.5	45.5
	Inpatient admissions and days of care per calendar year	8.2	11.1	0.0	15.0	4.7	11.8	4.5
	Outpatient consultations per calendar year	26.0	44.4	0.0	20.0	15.6	29.4	27.3
	Data reported to GLASS (Domains 3 and 4)	65.6	60.2	66.1	74.4	60.0	75.0	72.7
Domain 3	AST by infection type	54.4	38.9	62.5	65.0	48.0	73.5	67.0
	Bloodstream	78.4	57.4	71.4	85.0	82.8	91.2	95.5
	Gastrointestinal	64.4	66.7	85.7	95.0	26.6	97.1	77.3
	Urinary tract	41.8	16.7	50.0	45.0	45.3	67.6	45.5
	Urogenital gonorrhoea	33.2	14.8	42.9	35.0	37.5	38.2	50.0
Domain 4	Epidemiological, demographic and clinical information	76.8	81.5	69.6	83.8	71.9	76.5	78.4
	Number of sampled patients	65.9	87.0	50.0	90.0	46.9	58.8	68.2
	Patient's age	91.8	88.9	85.7	95.0	95.3	94.1	86.4
	Patient's gender	92.3	94.4	85.7	90.0	92.2	94.1	90.9
	Infection origin (community or hospital)	57.2	55.6	57.1	60.0	53.1	58.8	68.2
	TOTAL SCORE	53.8	56.0	46.7	61.0	46.7	61.2	55.8

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

BLOODSTREAM INFECTIONS

AMR surveillance coverage by WHO region

REGION	2023 COVERAGE	TREND	ANNUAL % CHANGE (RANGE)	NO. OF COUNTRIES
Western Pacific Region	528.8 (394.0, 771.1)	Stable	4.8 (−2.3, 12.4)	9
European Region	440.1 (384.7, 512.9)	Increasing	14.5 (6.6, 23.0)	31
Global	**120.3 (107.3, 139.6)**	Increasing	**20.0 (13.4, 26.8)**	**92**
Region of the Americas	64.6 (44.6, 103.3)	Increasing	18.1 (3.0, 35.8)	7
Eastern Mediterranean Region	36.1 (30.3, 44.6)	Increasing	24.0 (14.9, 33.8)	19
African Region	35.5 (25.8, 53.4)	Increasing	14.5 (5.0, 24.7)	17
South-East Asia Region	22.1 (16.8, 31.3)	Increasing	26.8 (11.7, 43.9)	9

Note: 2023 data; Coverage is presented as the number of bacteriologically confirmed infections with AST results reported to WHO GLASS per million population. Values in parentheses represent the credible confidence intervals

World Health Organization

GASTROINTESTINAL INFECTIONS

AMR surveillance coverage by WHO region

REGION	2023 COVERAGE	TREND	ANNUAL % CHANGE (RANGE)	NO. OF COUNTRIES
European Region	38.4 (31.0, 52.2)	Stable	9.9 (−2.0, 23.4)	18
Western Pacific Region	17.1 (12.9, 23.5)	Stable	−1.8 (−9.1, 6.3)	7
Region of the Americas	14.1 (10.4, 20.4)	Stable	4.2 (−9.1, 19.6)	6
Global	**8.3 (7.2, 9.9)**	Increasing	**11.4 (3.0, 20.4)**	**64**
Eastern Mediterranean Region	5.0 (4.1, 6.5)	Increasing	13.9 (3.6, 25.4)	16
African Region	3.0 (2.0, 5.2)	Stable	6.5 (−4.5, 18.9)	11
South-East Asia Region	0.5 (0.4, 0.8)	Increasing	17.4 (1.2, 36.1)	6

Note: 2023 data; Coverage is presented as the number of bacteriologically confirmed infections with AST results reported to WHO GLASS, per million population. Values in parentheses represent the credible confidence intervals

World Health Organization

URINARY TRACT INFECTIONS

AMR surveillance coverage by WHO region

REGION	2023 COVERAGE	TREND	ANNUAL % CHANGE (RANGE)	NO. OF COUNTRIES
European Region	10 368.1 (8063, 13 832)	Stable	5.8 (−6.8, 20.4)	10
Western Pacific Region	1880.3 (1360.3, 2795.4)	Stable	5.5 (−2.4, 14.0)	7
Global	**769.5 (644.5, 943.2)**	Increasing	**26.0 (17.3, 35.4)**	**62**
Region of the Americas	705.9 (473.7, 1218)	Stable	12.5 (−1.1, 28.4)	6
Eastern Mediterranean Region	211.2 (176.1, 264.9)	Increasing	37.8 (27.0, 49.3)	19
African Region	93.2 (57.5, 185.2)	Increasing	20.2 (8.2, 33.7)	12
South-East Asia Region	47.4 (35.4, 68.1)	Increasing	31.9 (15.5, 50.6)	8

Note: Coverage is presented as the number of bacteriologically confirmed infections with AST results reported to WHO GLASS, per million population. Values in parentheses represent the credible confidence intervals

World Health Organization

UROGENITAL GONORRHOEA INFECTIONS

AMR surveillance coverage by WHO region

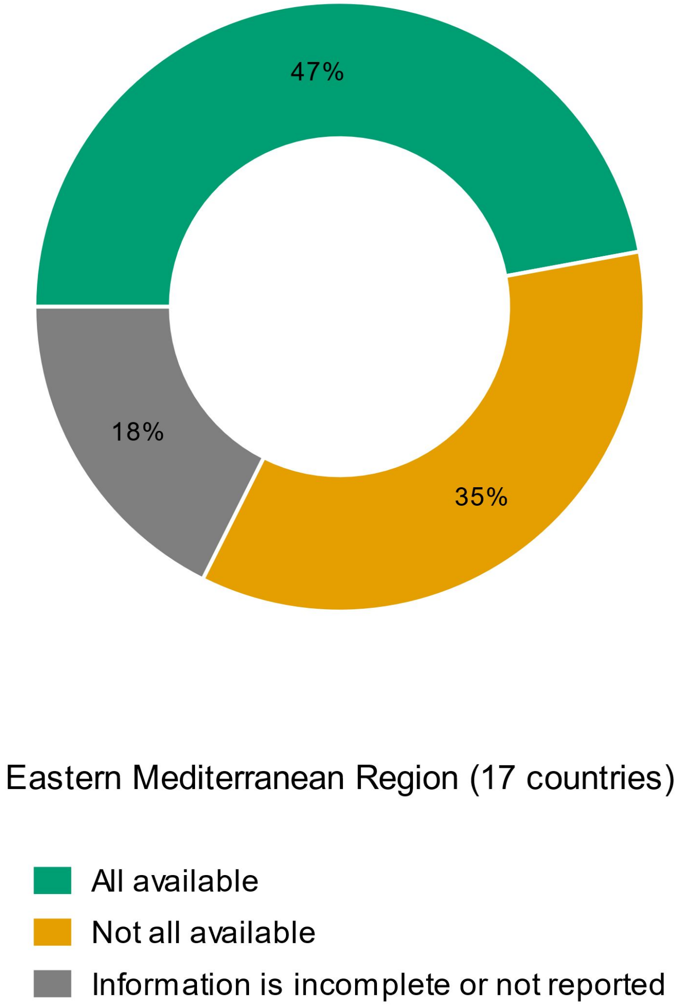
REGION	2023 COVERAGE	TREND	ANNUAL % CHANGE (RANGE)	NO. OF COUNTRIES
Western Pacific Region	18.9 (12.8, 30.9)	Stable	−9.3 (−17.9, 0.5)	6
Region of the Americas	10.4 (6.8, 18.0)	Stable	−8.0 (−22.5, 8.4)	5
European Region	9.6 (7.6, 12.8)	Stable	4.1 (−6.5, 16.0)	18
Global	**4.8 (3.9, 6.4)**	Stable	**−6.4 (−18.8, 7.8)**	**48**
African Region	2.0 (1.4, 3.3)	Stable	−7.4 (−25.2, 13.4)	6
Eastern Mediterranean Region	1.2 (0.9, 1.7)	Stable	4.5 (−9.7, 20.3)	10
South-East Asia Region	0.1 (0.1, 0.2)	Stable	−10.3 (−34.3, 22.2)	3

Note: 2023 data; Coverage is presented as the number of bacteriologically confirmed infections with AST results reported to WHO GLASS, per million population. Values in parentheses represent the credible confidence intervals

World Health Organization

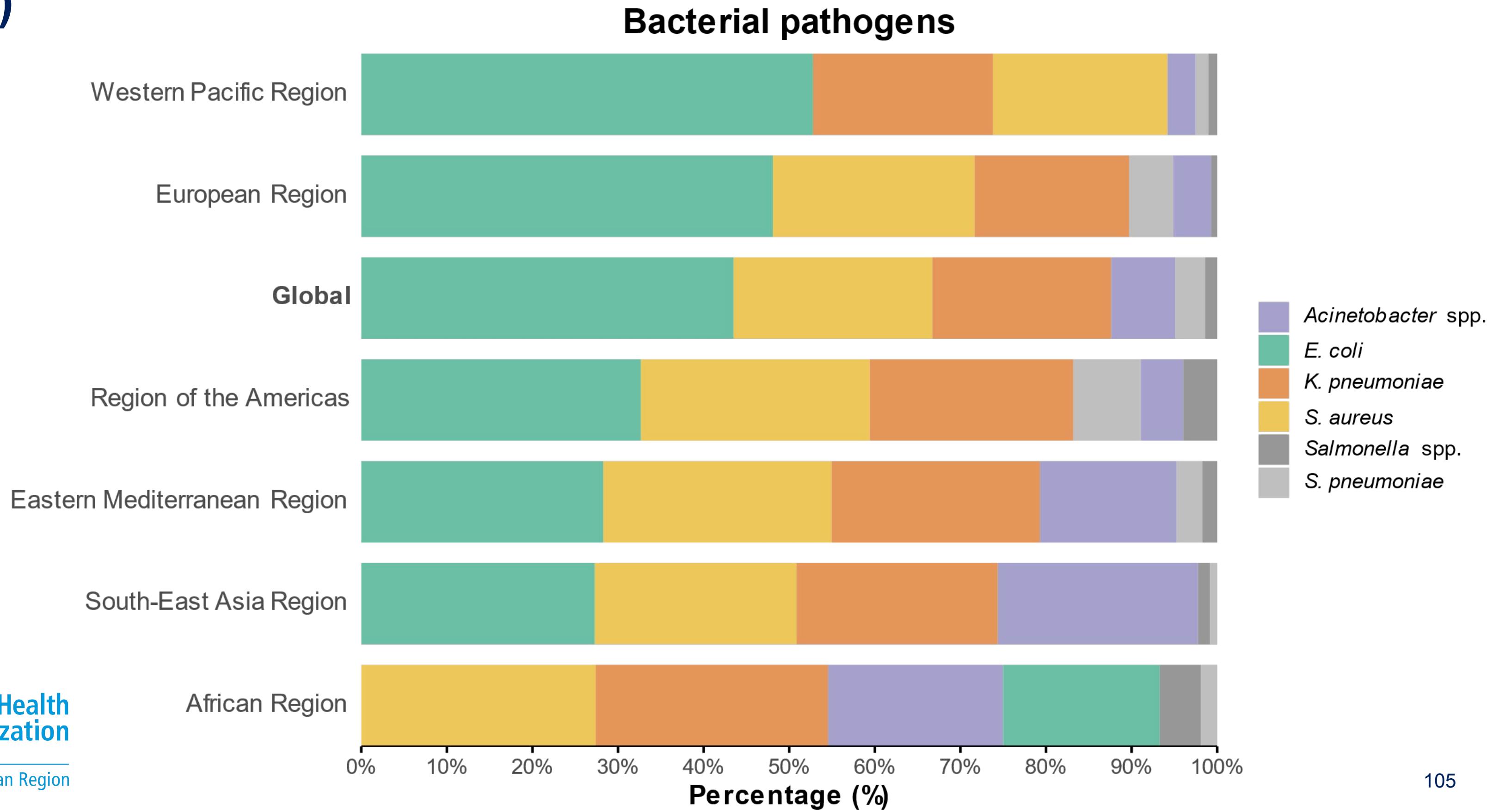
Implementation of the five core components of a national AMR surveillance system, 2023

The implementation status is presented for the pool of countries that reported 2023 AMR data to GLASS. An effective AMR surveillance system requires a national coordinating centre, a reference laboratory, external quality assurance of the reference laboratory, adherence to international AST standards, and external quality assurance of the laboratory network.



World Health Organization
Eastern Mediterranean Region

Global and regional distribution of bloodstream (BSI) pathogens (2023)



Resistance to common antibiotics by WHO region, 2023

South-East Asia Region
1 in 3
(31.7%)
of lab-confirmed bacterial infections are caused by resistant bacteria.

African Region
1 in 5
(19.6%)
of lab-confirmed bacterial infections are caused by resistant bacteria.

Region of the Americas
1 in 7
(14.7%)
of lab-confirmed bacterial infections are caused by resistant bacteria.

European Region
1 in 10
(10.2%)
of lab-confirmed bacterial infections are caused by resistant bacteria.

Western Pacific Region
1 in 11
(9.1%)
of lab-confirmed bacterial infections are caused by resistant bacteria.

Eastern Mediterranean Region
1 in 3
(30%)
of lab-confirmed bacterial infections are caused by resistant bacteria.

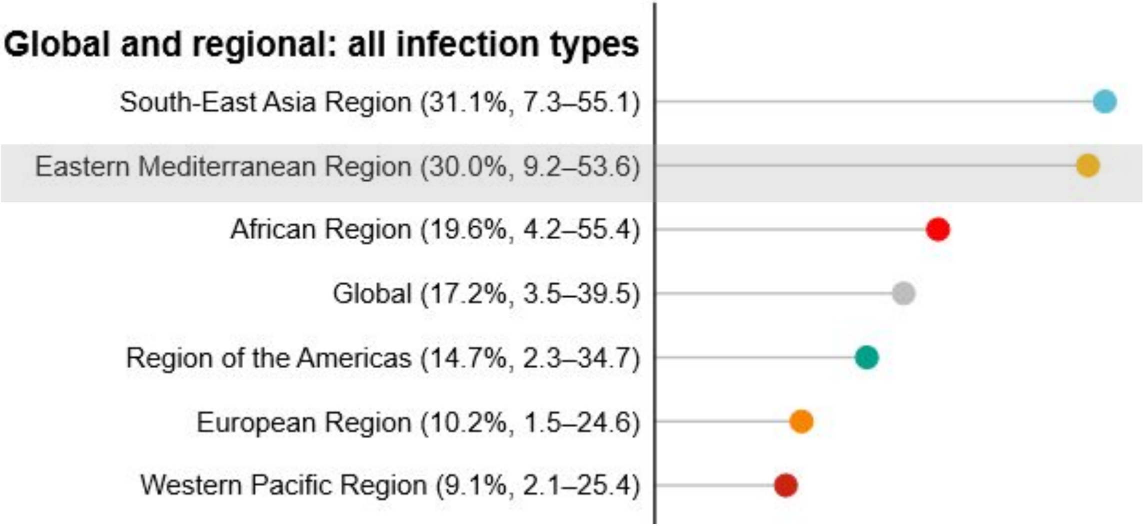
Data: median resistance across 93 drug-bug combinations

Resistance to common antibiotics by infection type and WHO region, 2023

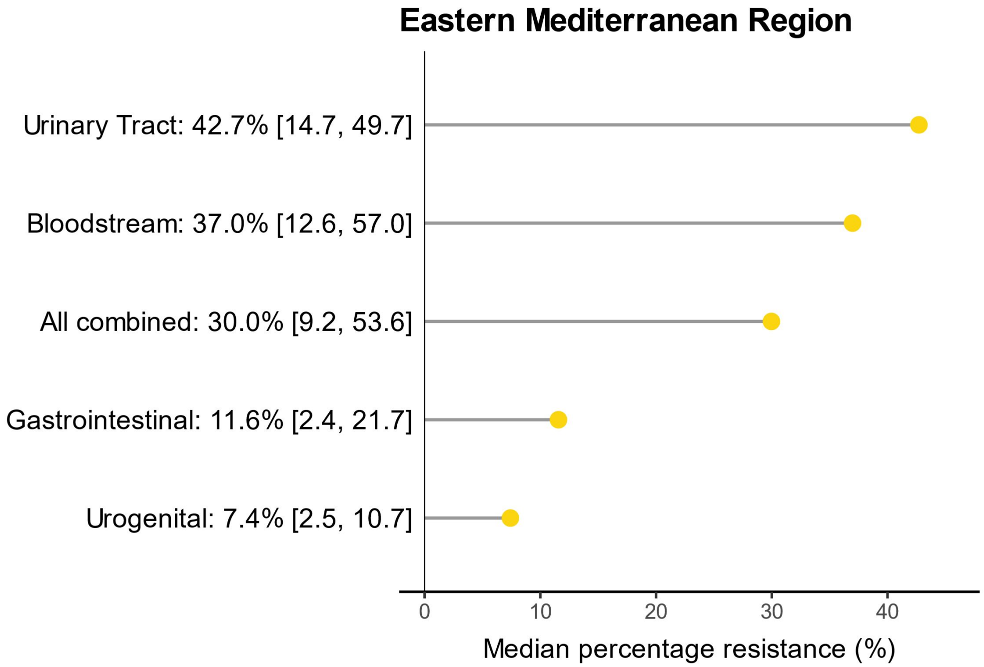
WHO Region	BSI (Bloodstream)	UTI (Urinary Tract)	GI (Gastrointestinal)	UG (Urogenital)
South-East Asia	1 in 4	1 in 2	1 in 7	1 in 40
Eastern Mediterranean	1 in 3	1 in 2	1 in 13	1 in 100
African Region	1 in 5	1 in 3	1 in 10	1 in 67
Region of the Americas	1 in 8	1 in 4	1 in 20	1 in 200
European Region	1 in 10	1 in 6	1 in 33	1 in 333
Western Pacific	1 in 13	1 in 7	1 in 25	1 in 250

Median percentage of resistance to antibiotics in the Eastern Mediterranean Region vs global and regional median

Median percentage AMR in 93 infection type–pathogen–antibiotic combinations, by WHO region, 2023



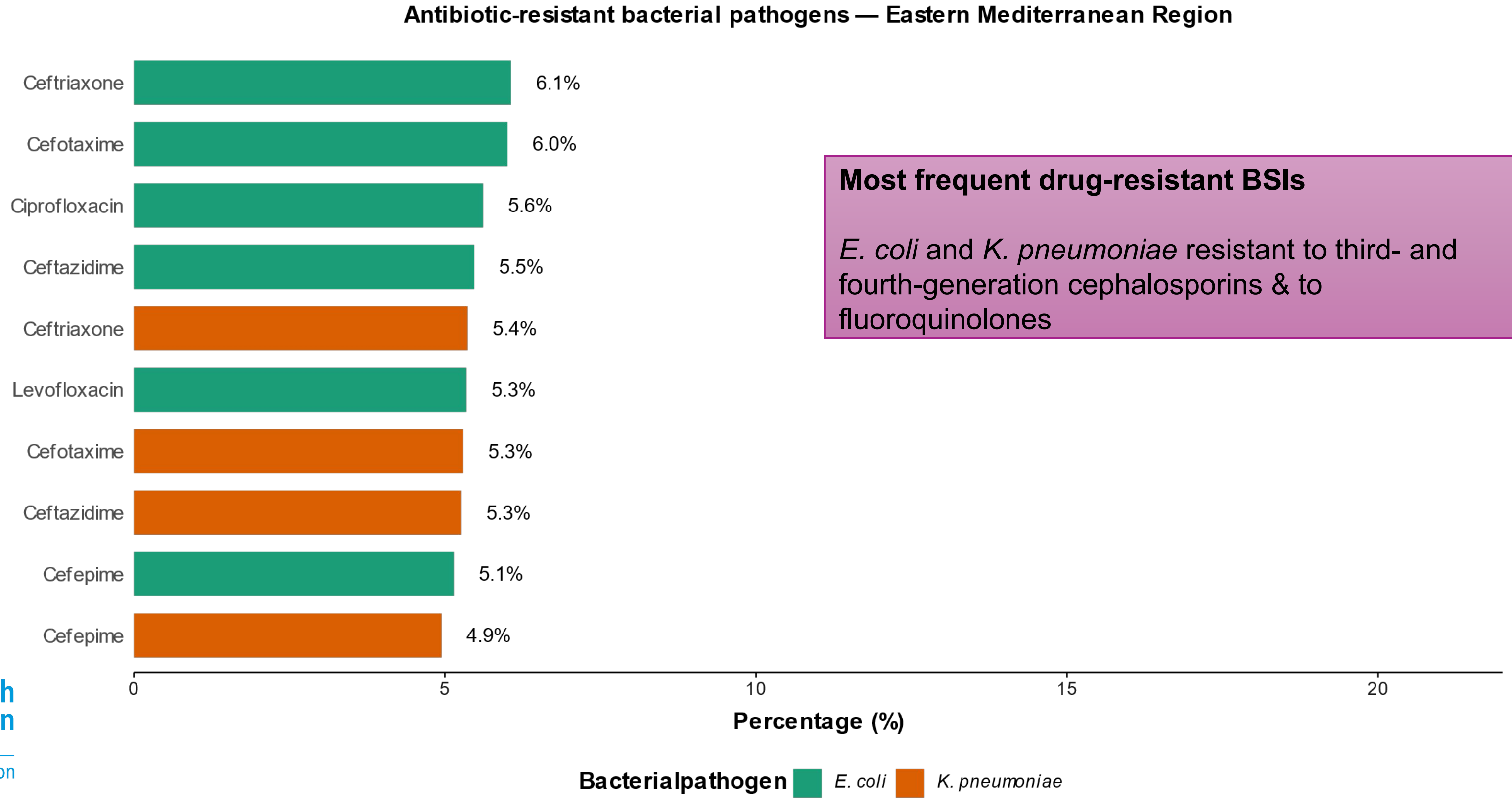
Median resistance to antibiotics by infection type, 2023



The median and interquartile ranges are useful summaries for comparing the levels of resistance among regions and infection types, but they do not reflect the full variation in resistance to specific infection–pathogen–antibiotic combinations.

World Health Organization
Eastern Mediterranean Region

Top drug-resistant bloodstream pathogens in EMRO

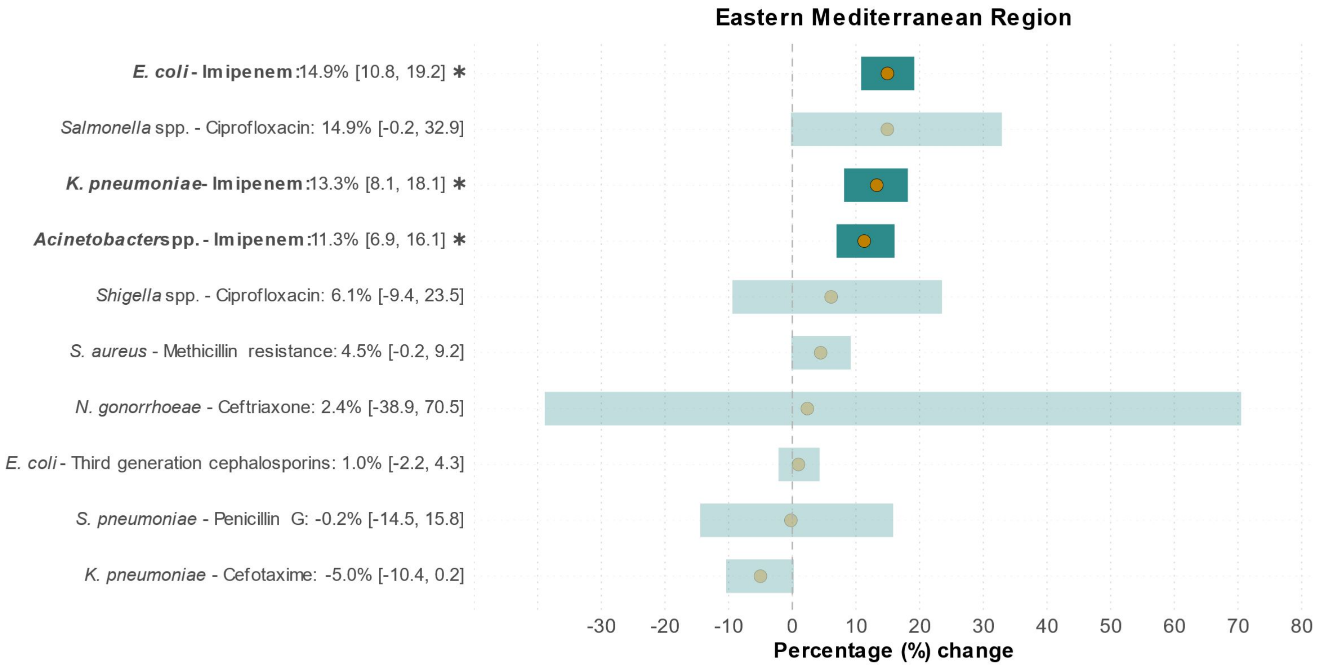


Most frequent drug-resistant BSIs

E. coli and *K. pneumoniae* resistant to third- and fourth-generation cephalosporins & to fluoroquinolones

World Health Organization
Eastern Mediterranean Region

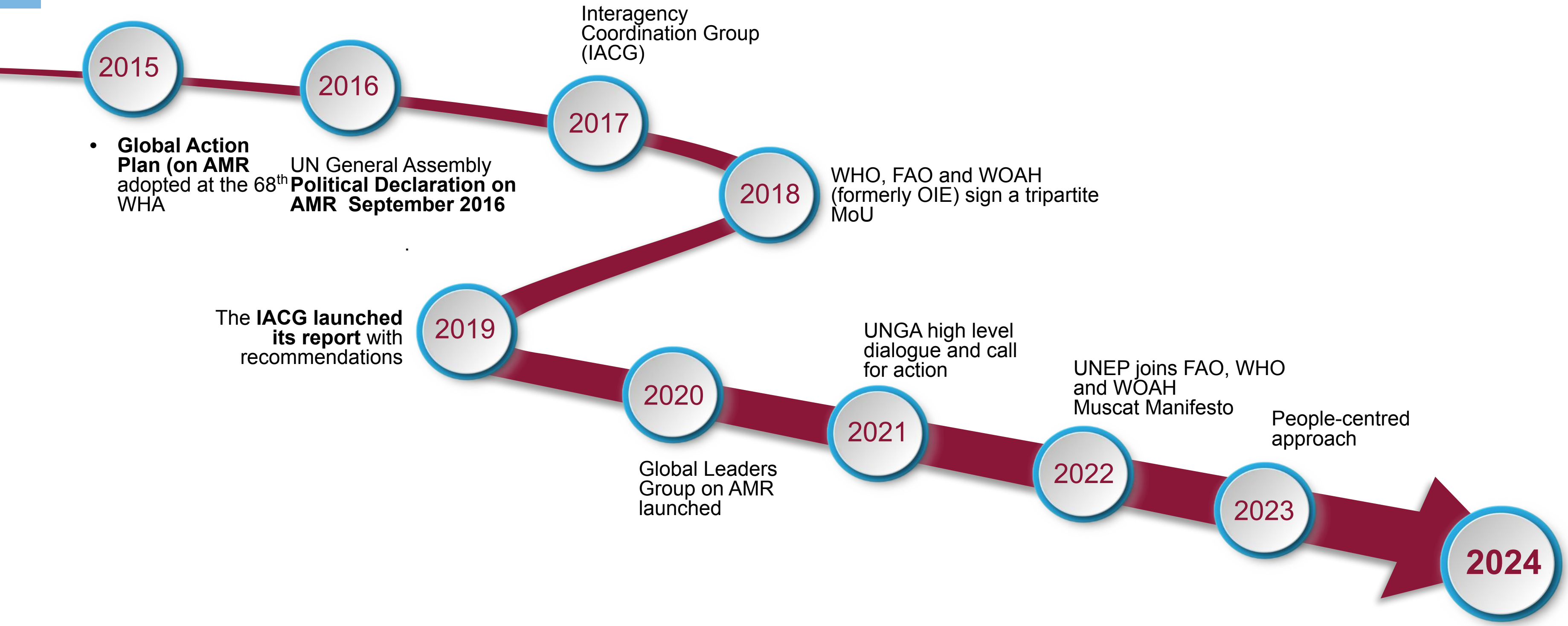
Trends in antibiotic resistance: average annual change,



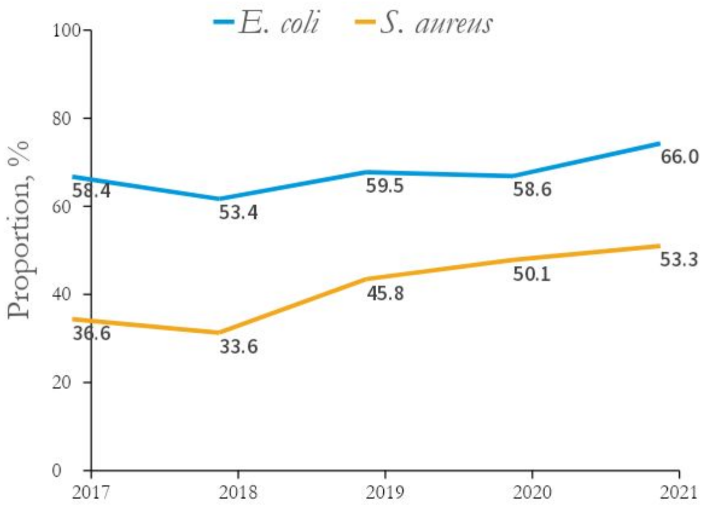
Population-weighted average annual percentage change in antibiotic resistance between 2018 and 2023, represented by a dot, with 95% CrI. An asterisk (*) indicates a statistically significant trend, defined by data from ≥5 countries over ≥3 years, and a 95% CrI that does not overlap with zero and has a bound of at least 1%. When trends were available for several infection types, only that with the highest annual percentage change is presented in the figure.

World Health Organization
Eastern Mediterranean Region

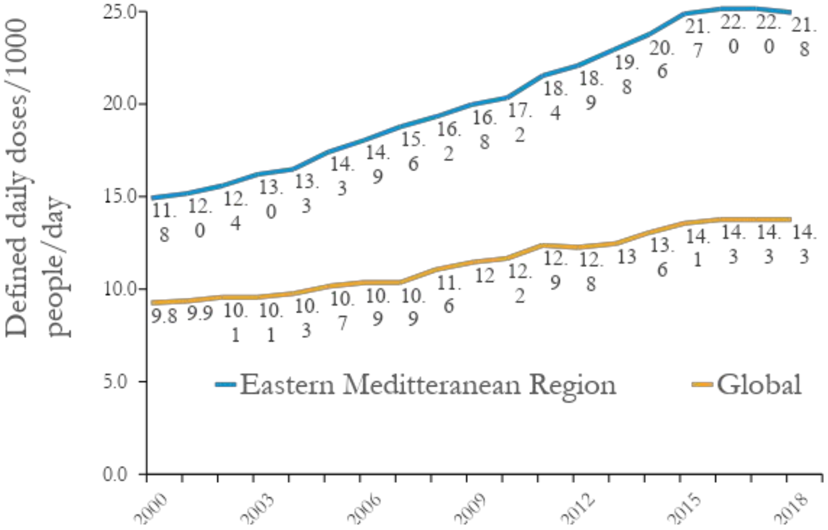
AMR – the road travelled



Proportion of methicillin-resistant *S. aureus* and third-generation cephalosporin resistant *E. coli* (GLASS)

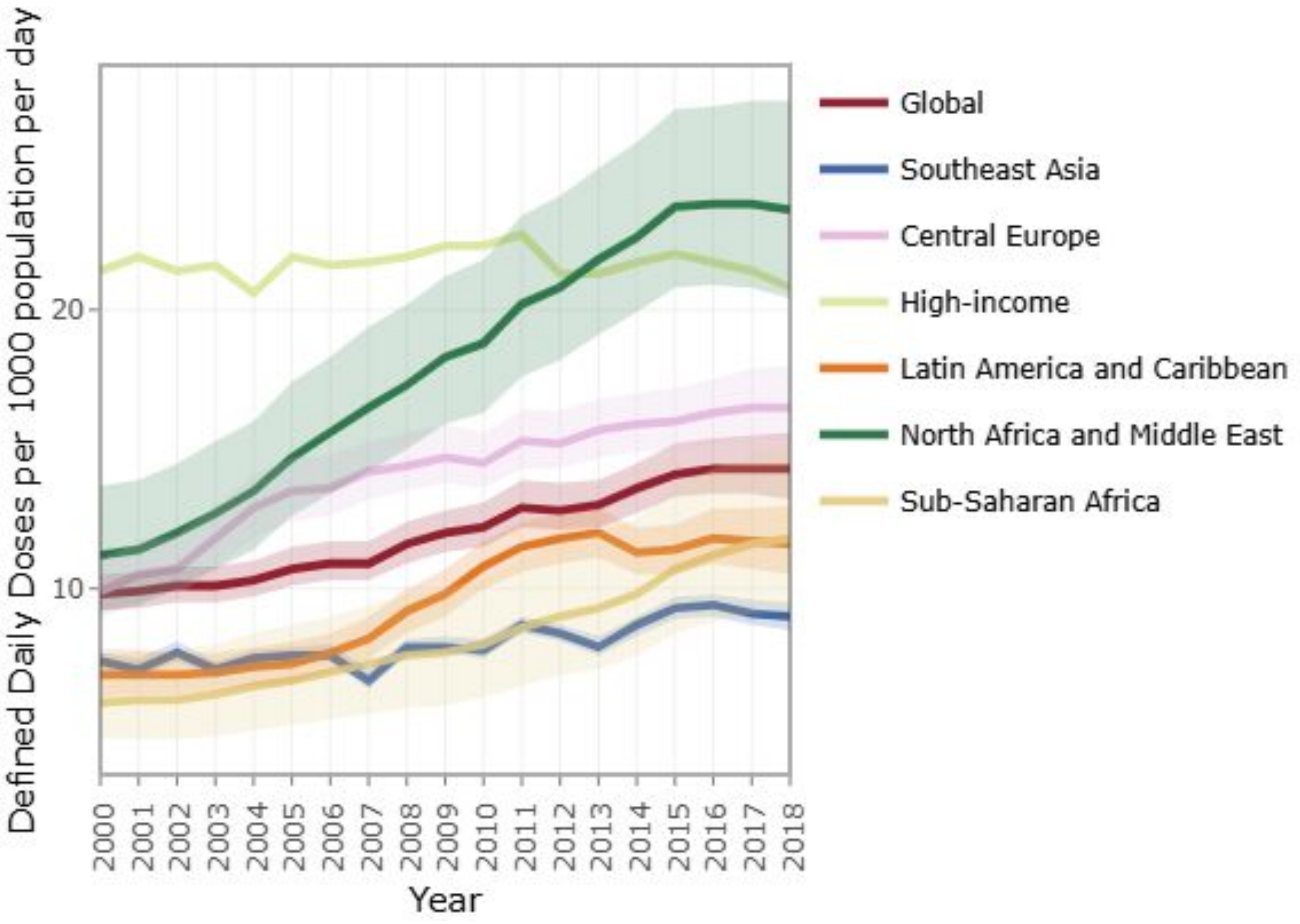


Mean estimated per capita antibiotic consumption (GRAM)



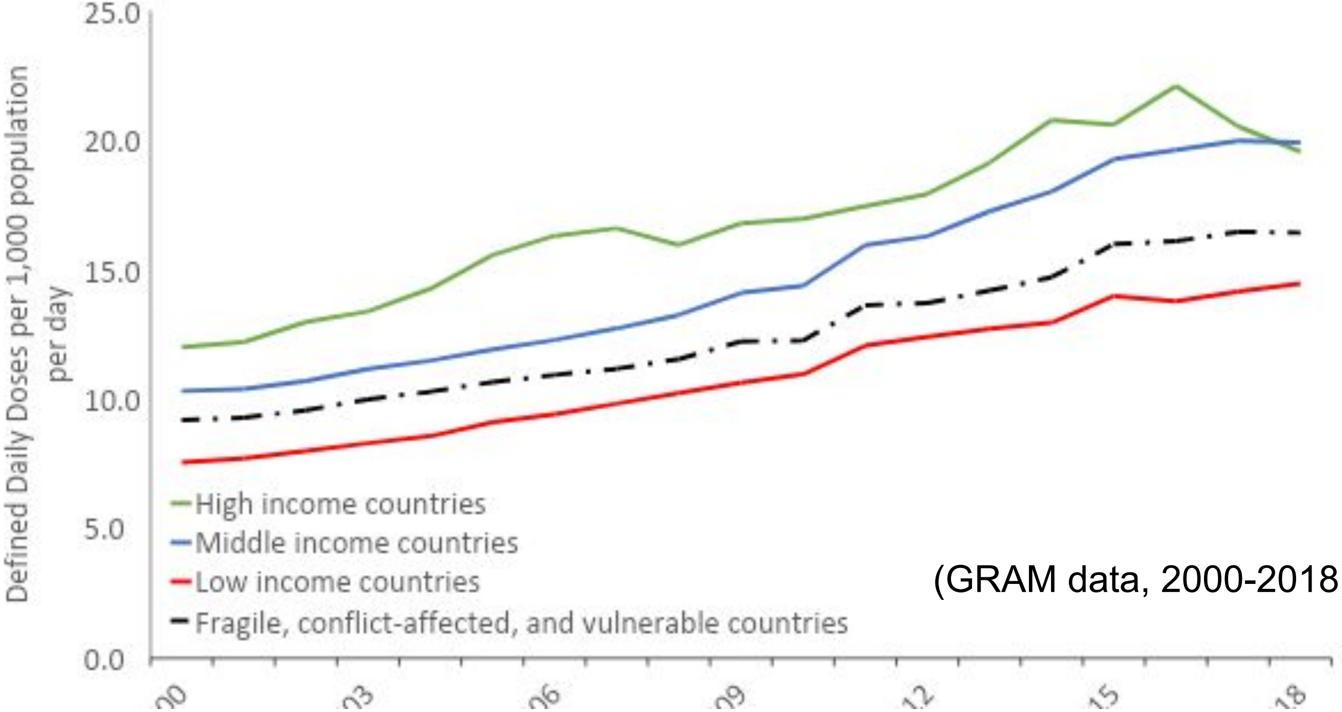
World Health Organization
Eastern Mediterranean Region

MENA antibiotic consumpti on



Region has the highest and most rapidly rising antibiotic use

But we also have inequities between countries within the Region



(GRAM data, 2000-2018)

Fragile conflict-affected and vulnerable includes all low-income countries and a few middle-income

WHO GLASS data: Summary of AMR and AMU use

MRSA in bloodstream infections, an SDG indicator, was 50.3%, the highest amongst all WHO regions.

Acinetobacter resistance to imipenem was 66.5%, the highest figure globally, and it is rising by 11.3% annually, the highest increase among WHO regions.

Salmonella resistance to ceftriaxone stood at 56.9%, the highest among WHO regions.

Antibiotic use was highest: 23.0 defined daily doses per 1000 inhabitants per day (DID) in the Eastern Mediterranean.

Only 4 countries out of the 9 countries which submitted data for 2023 from the Eastern Mediterranean region achieved the 60% Access (2023 target).

Only 1 country in the region—Tunisia—has achieved the 2030 target (70% Access) set by the UN General Assembly in 2024.

Regional progress so far

1	2	3	4	5	6
21 countries developed their first AMR national action plans	**22 countries** enrolled in the WHO Global AMR surveillance system	**18 countries** set-up dedicated IPC units or programs	**20 countries** enrolled in GLASS antimicrobial use surveillance	**9 countries** adopted the WHO AWaRe classification in the national essential medicines list	**Regional guidance on antibiotic use** tailored for conflict-affected settings

World Health Organization
Eastern Mediterranean Region

How did we identify the priorities?

- TrACSS data
- GLASS data
- IPC global surveys, e-SPAR
- Regional consultation meeting on stewardship
- Regional Lab capacity assessment survey
- WASH & Immunization data

Key underlying principles

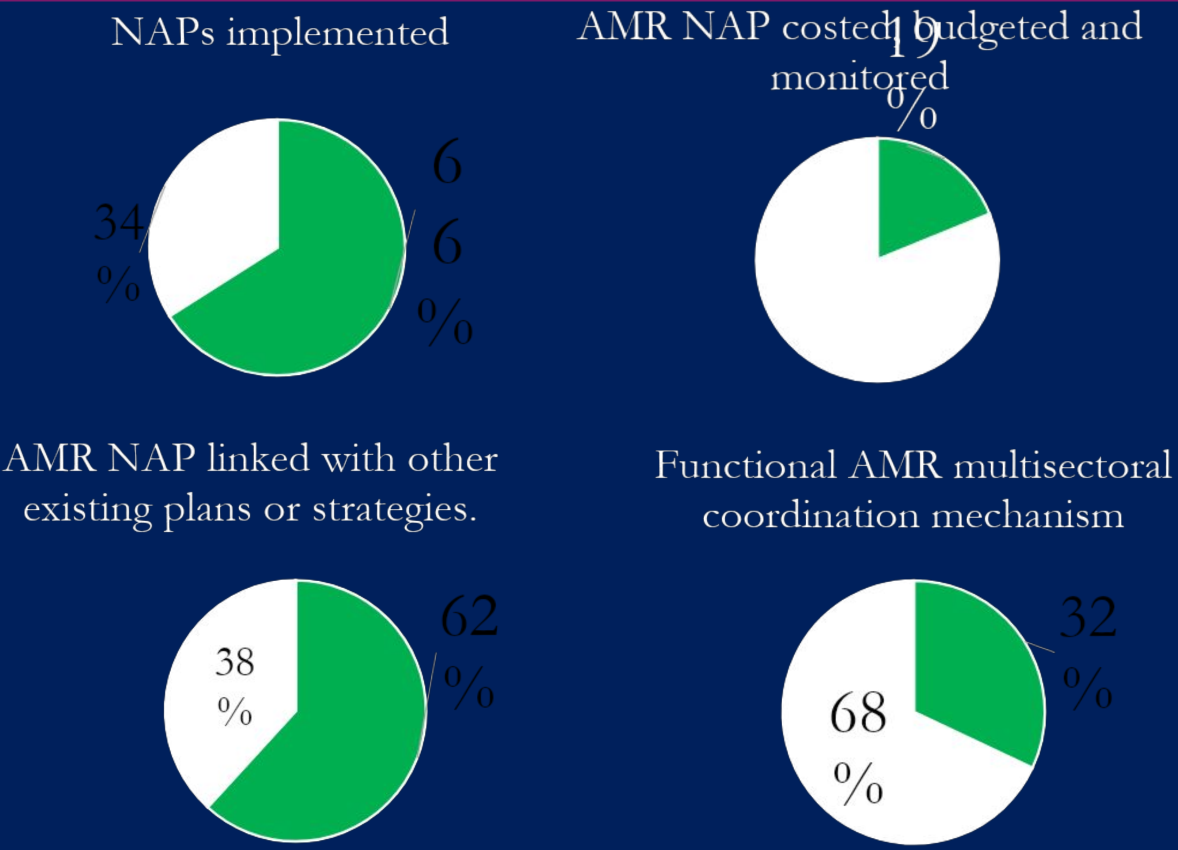
- People centred approach/WHO strategic and operational priorities
- Collaborative action
- One Health
- Resilient health systems for UHC and health security
- Fragile conflict-affected and hardly reached populations are adequately covered

World Health Organization
Eastern Mediterranean Region
Regional Committee for the Eastern Mediterranean
Seventy-first session

World Health Organization
Eastern Mediterranean Region

Governance, One Health coordination

- Costed budgeted monitored multi-sectoral AMR NAPs
- Coordination within human health



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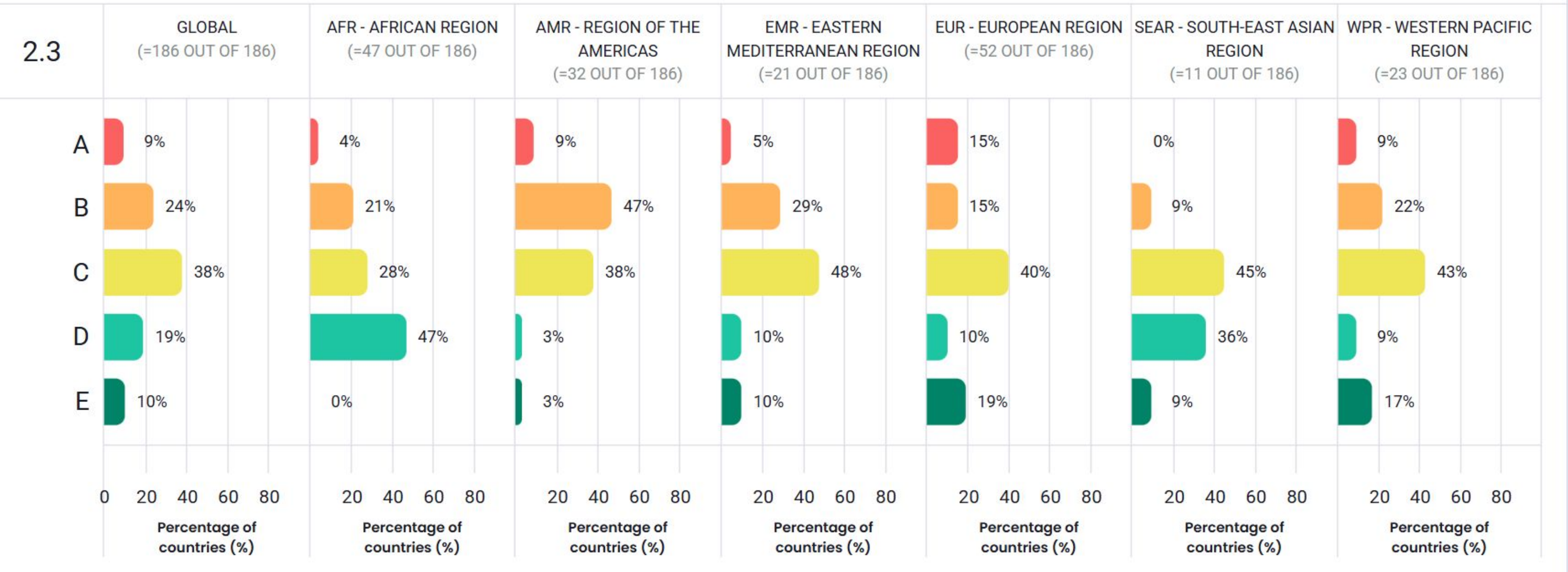
Eastern Mediterranean Region

Status of National Action Plan funding



- A — No national AMR action plan or plan under development.
- B — National AMR action under development.plan developed.
- C — National AMR action plan approved by government and is being implemented.
- D — National AMR action plan has costed and budgeted operational plan and has monitoring mechanism in place.
- E — Financial provision for the National AMR action plan implementation is included in the national plans and budgets.
- Did not respond

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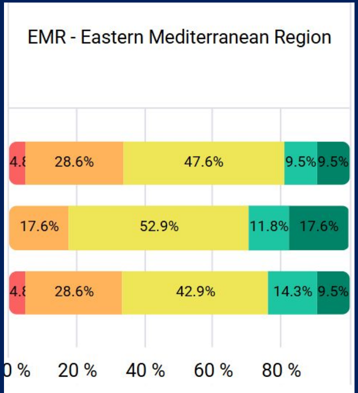
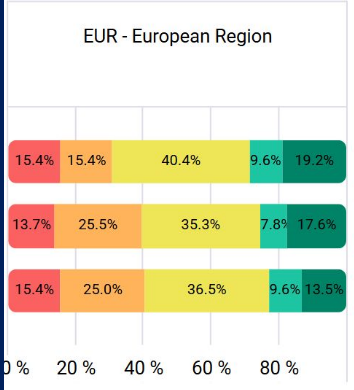
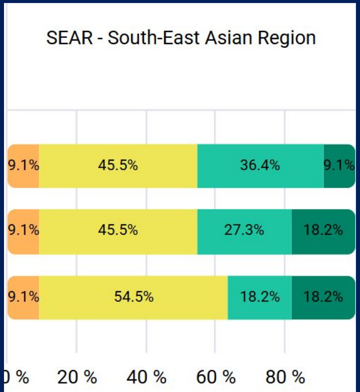
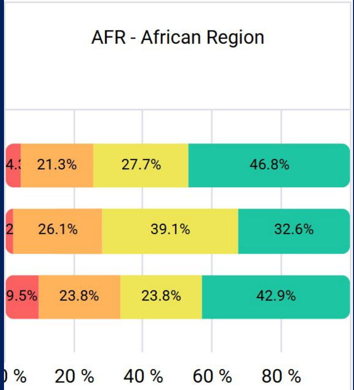
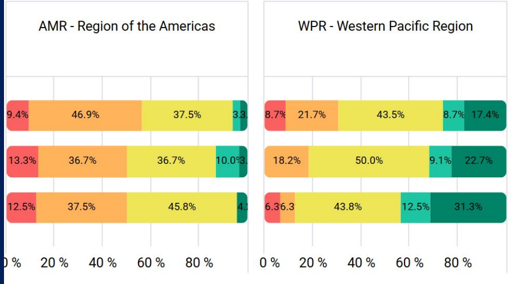
Progress in National Action Plan funding

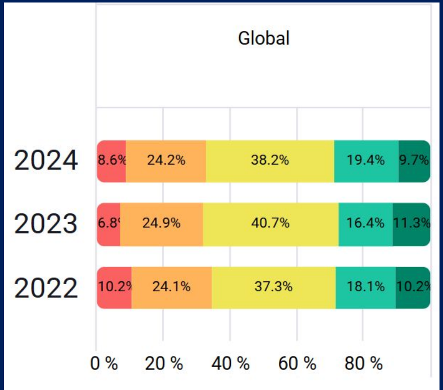












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United Nations General Assembly (UNGA) High-Level Meeting on AMR
Goals / targets for 2030

90 per cent of countries meet WHO's minimum requirements for IPC at national level

100 per cent of countries have basic WASH and waste services in all health care facilities

Reduce global deaths due to AMR by 10%.

70% of human antibiotics come from the ACCESS.

Animal vaccination strategies are defined with an implementation plan

At least 80 per cent of countries can test resistance in all bacterial and fungal GLASS pathogens by 2030

Meaningfully reduce the quantity of antimicrobials used globally in the agri-food system from the current level

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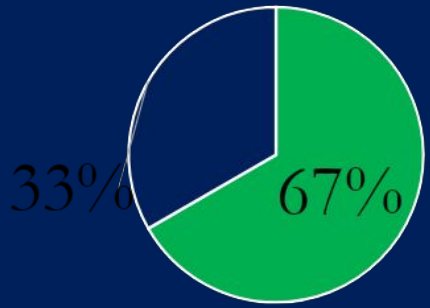
UNGA HLM

- Calls for sustainable national financing
  - US$100 million in catalytic funding,
  - At least 60% of countries having funded national action plans by 2030.
- Diversifying funding sources
- Securing more contributors to the Multi-Partner Trust Fund.

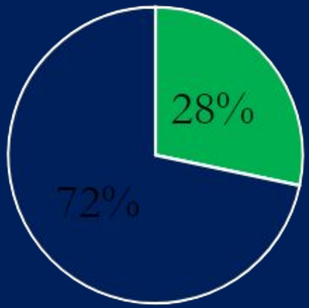
Awareness, Education

- Wider engagement of youth, NGOs, professional societies, medical students, prescribers, women
- Fellowships, certificate programs, massive online courses, integration to undergraduate education

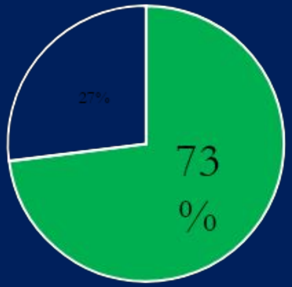
Some awareness at least at local level



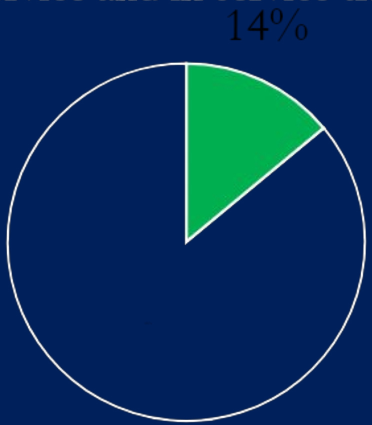
Nationwide AMR awareness campaigns



Offer at least some AMR training



Pre service and in service training



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Eastern Mediterranean Region

Regional status of vaccine coverage (2024)

Vaccine coverage varies between countries, but also within countries for different vaccines.

15 out of 22 countries achieved coverage of 90% or higher in at least one vaccine.

	BCG	HepBB	DTP1	DTP3	Hib3	HepB3	PCV3	RotaC	Pol3	IPV1	IPV2	MCV1	RCV1	MCV2	YFV	MengA	HPVc
Oman	99	99	99	99	99	99	99		99	99	99	99	99	99			
Kuwait	99	93	99	99	99	99	96	88	99	99	99	98	98	94			
Egypt	98	95	99	97	97	97			97	99	98	97	97	96			
Qatar	99	99	99	96	96	96	96	95	98	99	98	99	99	99			1
Iran	99	94	98	98	98	98	0	2	99	99	99	99	99	99			
Morocco	98	80	98	96	96	96	77	92	96	95		98	98	98			3
Tunisia	98	73	97	97	97	97	97		96	96	96	96	96	97			
Saudi Arabia	97	97	97	97	97	97	96	97	97	97	97	96	96	96			
Bahrain		99	97	96	96	96	99	94	98	97	97	99	99	99			
Jordan	90	0	97	96	96	96		93	94	97	96	99	99	96			
Iraq	95	48	97	90	90	90	65	64	91	95	91	91	91	82			
UAE	96	94	96	96	96	93	94	90	95	96	94	98	98	92			46
Pakistan	96	25	94	87	87	87	87	90	87	87	84	86	86	82			
Libya	85		90	86	86	86	89	82	86	90	89	89	89	80			28
Palestine	87	84	88	88	88	91	87	83	89	86	86	89	89	89			
Lebanon		80	86	49	51	46	67	45	47	86	69	67	67	59			
Djibouti	77	77	82	77	77	77	76	84	77	82	58	75		48			
Syria	84	34	81	73	73	73			75	81	75	81	81	75			
Somalia	74		78	70	70	70			71	70	50	64		32			
Afghanistan	68	53	66	59	59	59	57	56	59	59	49	55		44			
Yemen	50		53	42	42	42	41	42	42	45	35	41	41	40			
Sudan	49		48	39	39	39	40	37	40	50	41	46	46	36	45	46	

<60% 69% 70- 89% 90-94% >=95%

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Eastern Mediterranean Region

Prevention of infection

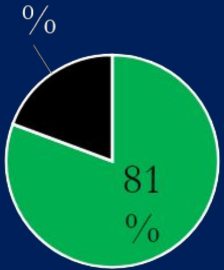
- Universal access to WASH
- Implementation of IPC minimum requirements
- Expanding immunization coverage:
  - *Typhoid, Pneumococcus, Influenza and Rotavirus*

Standards available for WASH and waste in health care facilities

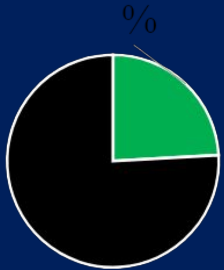
Access to quality assured affordable essential health services

- Pooled procurement and increased local production
- Integrate stewardship and IPC at PHC and in Emergency response
- Fit-for-purpose workforce
- Improved uptake of AWaRe guidelines, Mobile App, AI tools
- Restrictions on sales without compromising access

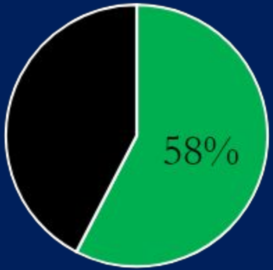
Compulsory EQA in at least some labs



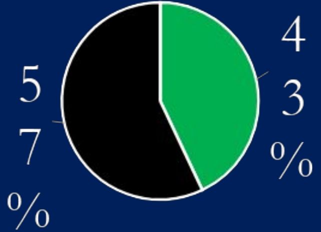
Stock-outs reporting mechanisms



Antibiotics guidelines in at least some health facilities



Adopted AWaRe into national essential medicine list



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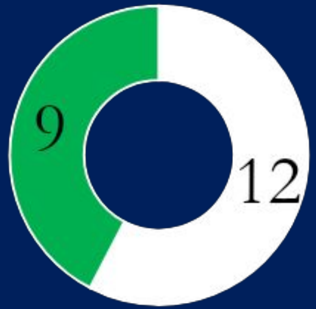
Strategic information through surveillance and research

- Diagnostic stewardship
- Sustainable models of AMR and HAI surveillance network—quality assured representative data
- Engagement of procurement agencies, drug regulators, CDCs in analysing and using antibiotic data for action
- Engagement of agri-food, veterinary, environmental sectors in surveillance
- Behavioural and implementation science research

AST capacity for at least some priority pathogens

Have a standardized AMR surveillance system



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Eastern Mediterranean Region

Thank you

koyas@who.int

One Health Approach to Antimicrobial Resistance in Fragile Health Systems: The Case of Palestine

Dr. Said F. Abukhattab

Scientific Researcher, Institute of Community and Public Health, Birzeit University, Birzeit University (Palestine)

Dr. Said F. Abukhattab

Scientific Researcher in Epidemiology,
Institute of Community and Public Health,
Birzeit University, Birzeit University (Palestine)

Q&A

Closing Remark & Announcement

THE GLOBAL HEALTH NETWORK
Enabling research by sharing knowledge

WORLD AMR AWARENESS WEEK
18-24 NOVEMBER

Thank You!

Thousands of global health professionals, like you, have taken part in free webinars and workshops hosted by The Global Health Network.

Your support keeps these sessions free for researchers and health workers everywhere, helping them conduct studies even in times of crisis.

Please give what you can today:
https://hub.tghn.org/support-us/donate/

Thank you for joining.

One Health Approach to Antimicrobial Resistance in Fragile Health Systems: The Case of Palestine.

Dr. Said Abukhattab

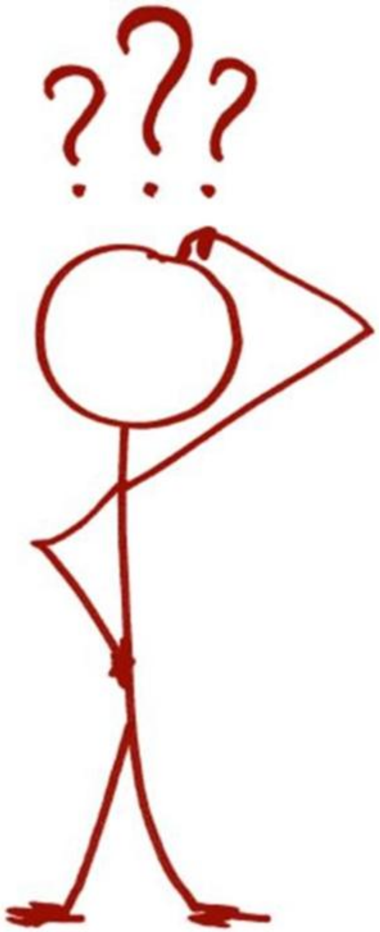
MPH|Ph.D in Epidemiology

Infectious Disease and One Health Group
Institute of Community and Public Health (ICPH)
Birzeit University, Ramallah, Palestine

Guest Scientist
Swiss Tropical and Public Health Institute
University of Basel, Basel, Switzerland

November 21, 2025

Before We Treat, Let’s Rethink: Big Questions on AMR



- Can AMR truly be controlled in hospitals without an integrated One Health surveillance system across humans, animals, food systems, and the environment?
- What would an effective early-warning system for AMR look like in humanitarian settings — and why is it still missing across sectors today?
- Who owns AMR data, and how does the lack of cross-sectoral data sharing weaken our collective capacity to respond to emerging resistance threats?

Antimicrobial Resistance (AMR):

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 *(WHO).* AMR is a critical global concern driven by the overuse, misuse, and/or usage of inadequate antimicrobials on humans, animals, and as a result of contaminated environments *(Abukhattab et all,.)*.

Earthquake Versus Slow Tsunami

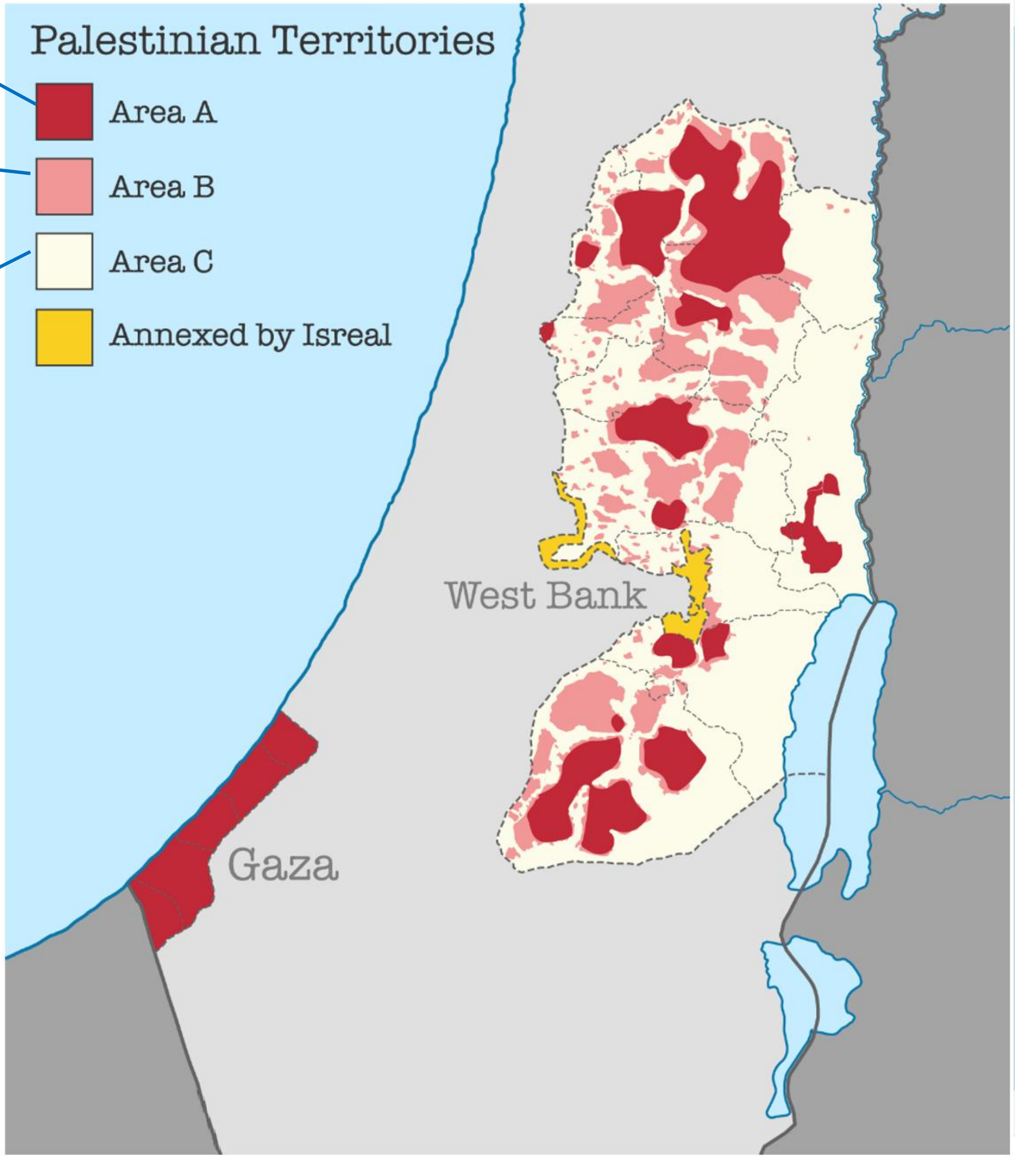
Criteria	COVID-19	AMR
How deaths associated with?	6.9 million total	5 million, projected to rise to >10 million/year
Who was/will be affected?	Elderly and co-morbidities	Neonates, Paediatrics, Women
How much money did/will it cost?	12-14 trillion USD	>100 trillion USD
Which countries were affected?	HIC/MIC	LMIC
Can it be fixed by vaccination?	Yes (vaccine wars!)	No
Can diagnostics be quickly implemented?	Yes	No

A geopolitical map of Palestine (the West Bank and Gaza Strip)

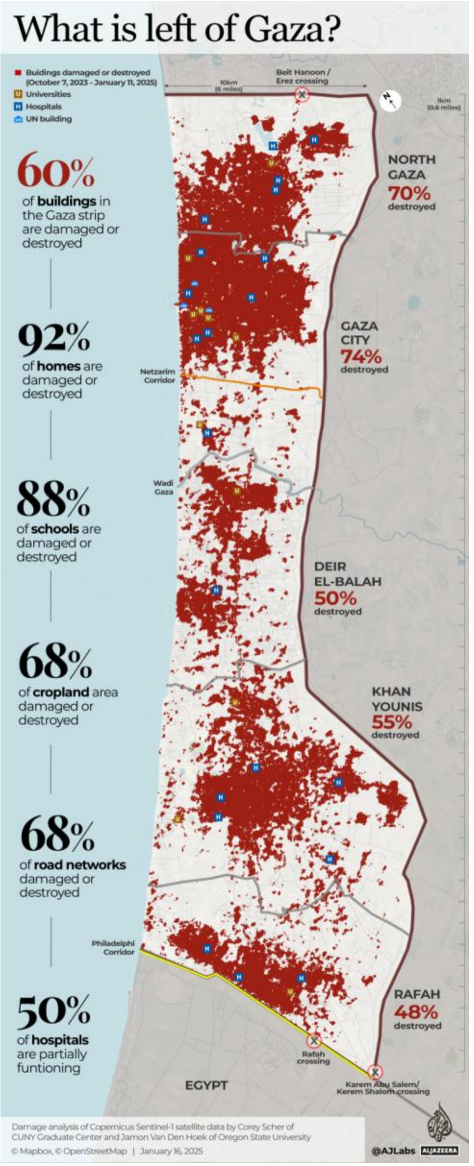
Palestinian political & police control

Palestinian political control “shared” police control

Israeli political & military control



Adapted from: https://www.anera.org/



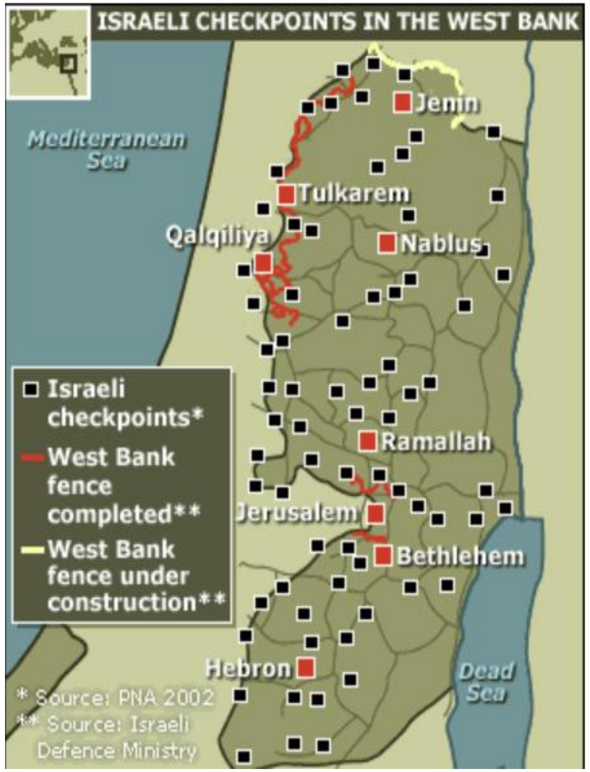
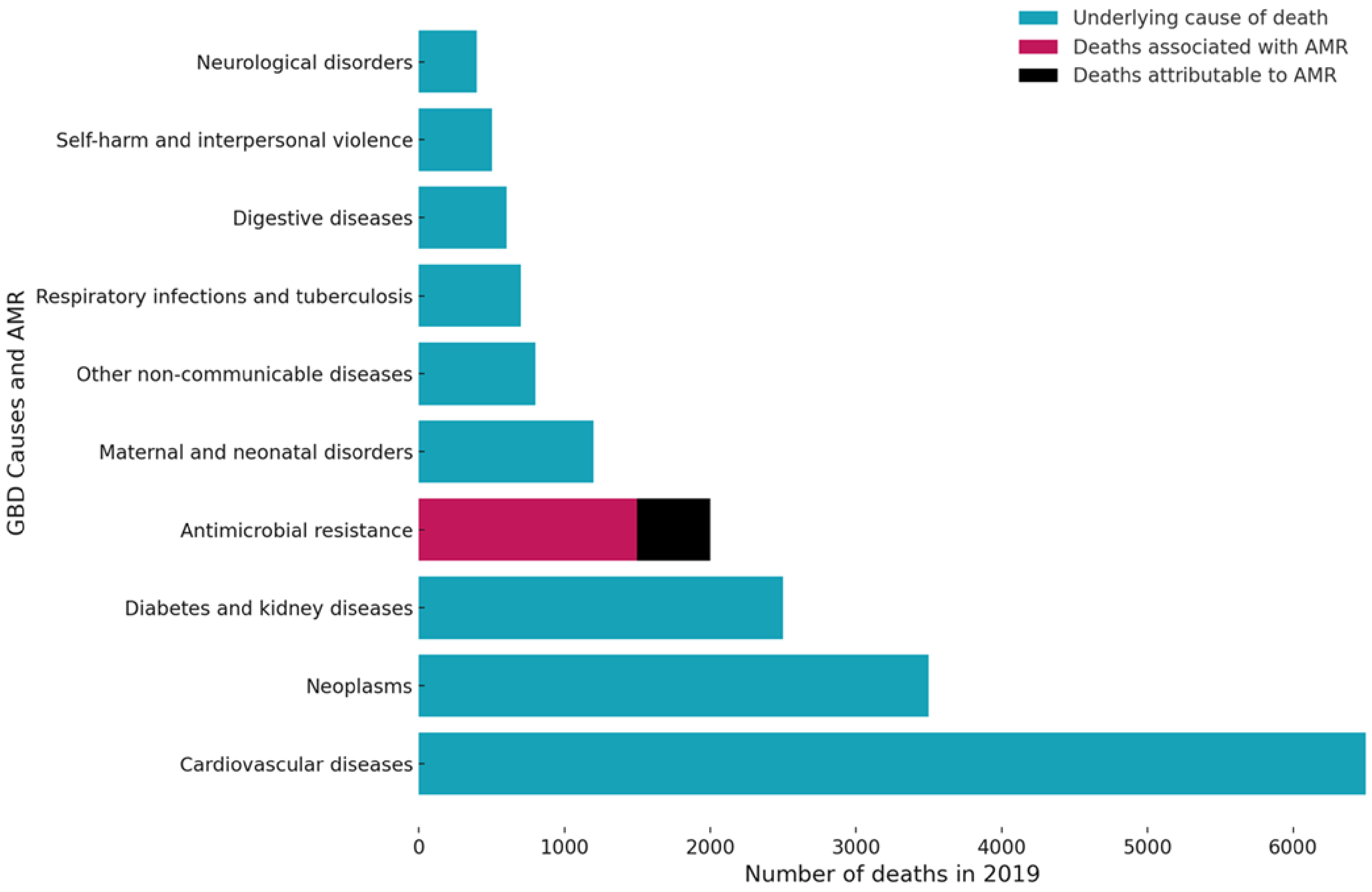


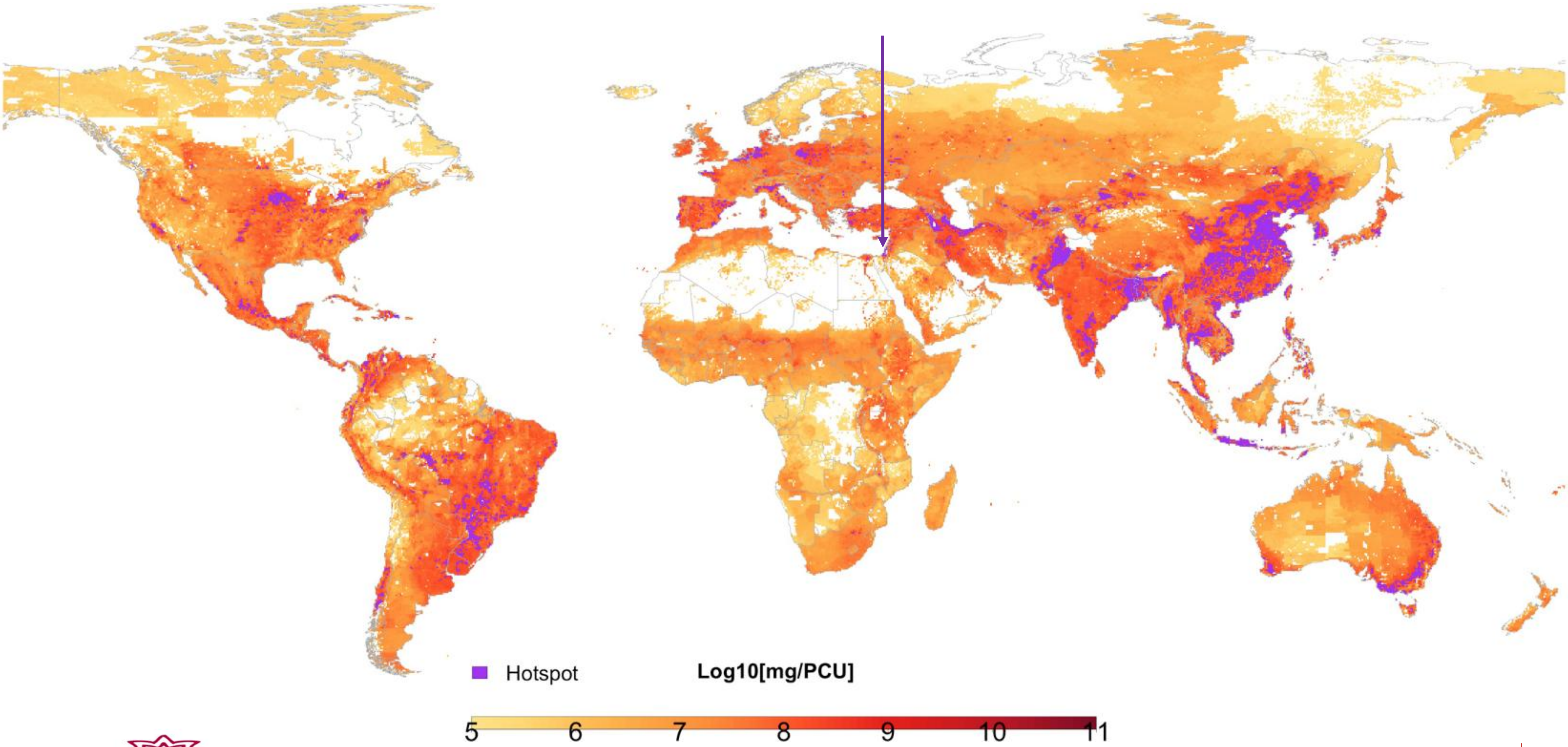
Photo source: BBC and Aljazeera

Placing AMR in context with other causes of death in 2019, Palestine



The length of each bar indicates the number of deaths by GBD cause and those associated with/attributable to AMR in 2019.

Global veterinary antimicrobial consumption



(Mulchandani et al., 2023)

National Action Plan for antimicrobial resistance (NAP AMR)

BIRZEIT UNIVERSITY

Improve public awareness

Optimize the use of antimicrobial medicines

Strengthen national One-Health surveillance

Implement evidence-based infection control practices

Encourage and promote operational research

Institute of Community and Public Health

Making Food Safer in Palestine: A One Health Approach to Antimicrobial Resistance

2020-2023

Antimicrobial Resistance among the leading Food-borne and Gastroenteritis pathogens

Institute of Community and Public Health

Systematic Review on foodborne related One Health studies

antibiotics

MDPI

Systematic Review

Systematic Review and Meta-Analysis of Integrated Studies on Salmonella and Campylobacter Prevalence, Serovar, and Phenotyping and Genetic of Antimicrobial Resistance in the Middle East—A One Health Perspective

Said Abukhattab [1,2,*], Haneen Taweel [3], Arein Awad [3], Lisa Crump [1,2], Pascale Vonaesch [4], Jakob Zinsstag [1,2], Jan Hattendorf [1,2] and Niveen M. E. Abu-Rmeileh [3]

Study Main Findings

- One Health approach was not rigorously applied.
- Weak epidemiological designs.
- Insufficient laboratory techniques to monitor antimicrobial resistance.
- Significant variation in data reports between countries: 60% from "Egypt", no data from the Gulf countries.

(Abukhattab et al., 2022)

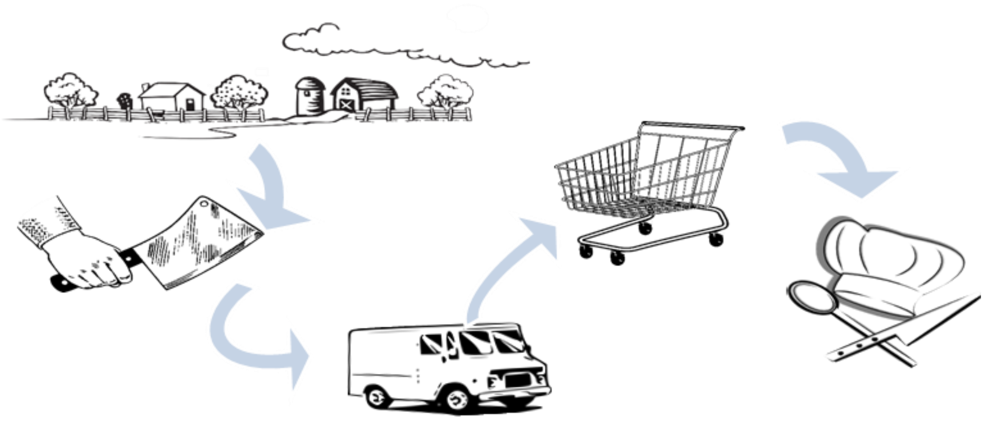
Mixed-Method study results

antibiotics MDPI

Article

Towards a One Health Food Safety Strategy for Palestine: A Mixed-Method Study

Said Abukhattab [1,2,*], Miriam Kull [1,3], Niveen M. E. Abu-Rmeileh [4], Guéladio Cissé [1,3], Lisa Crump [1,3], Jan Hattendorf [1,3] and Jakob Zinsstag [1,3]



Study Main Findings

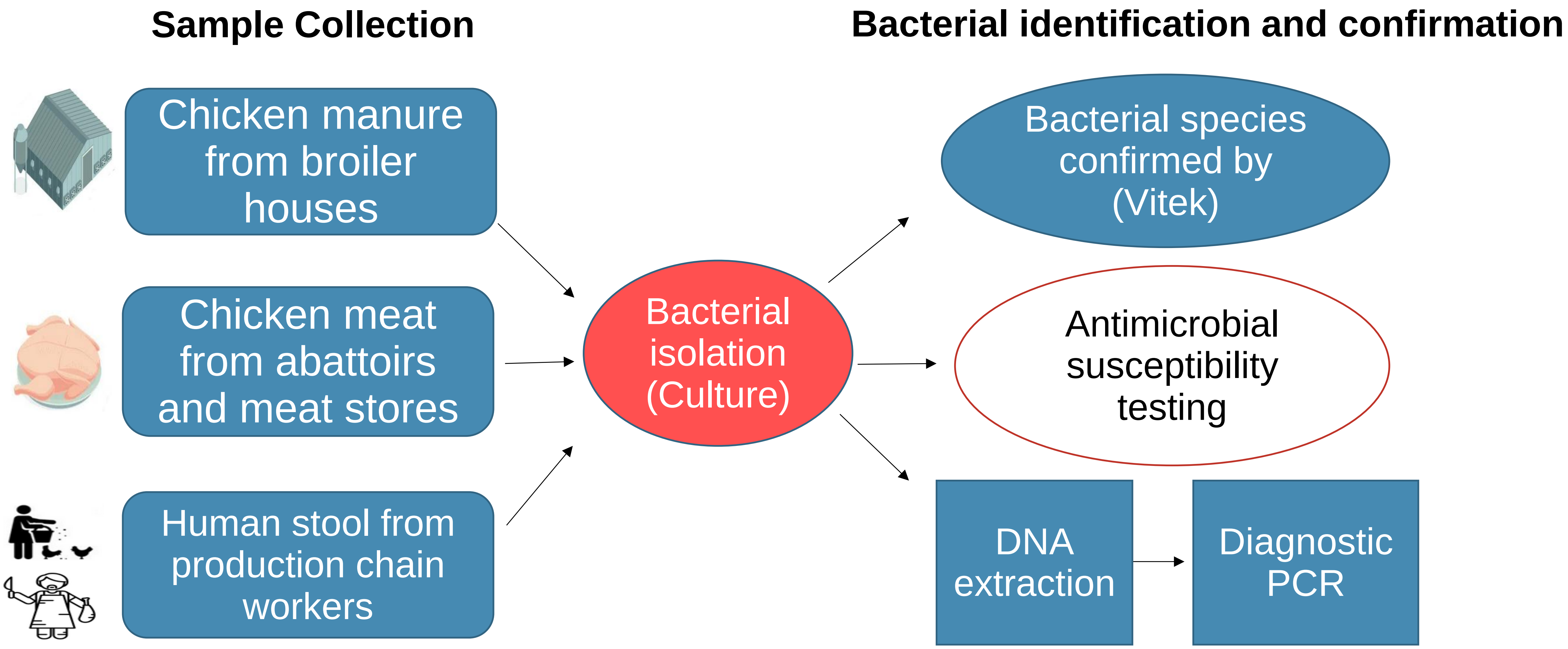
➢ The main obstacles to improving food safety and AMR in Palestine are:

Overuse of antimicrobials	System fragmentation	Insufficient infrastructure
A lack of regulations and controls	Poor hygiene practices	

❖ A comprehensive national integrated surveillance system must be established in Palestine.

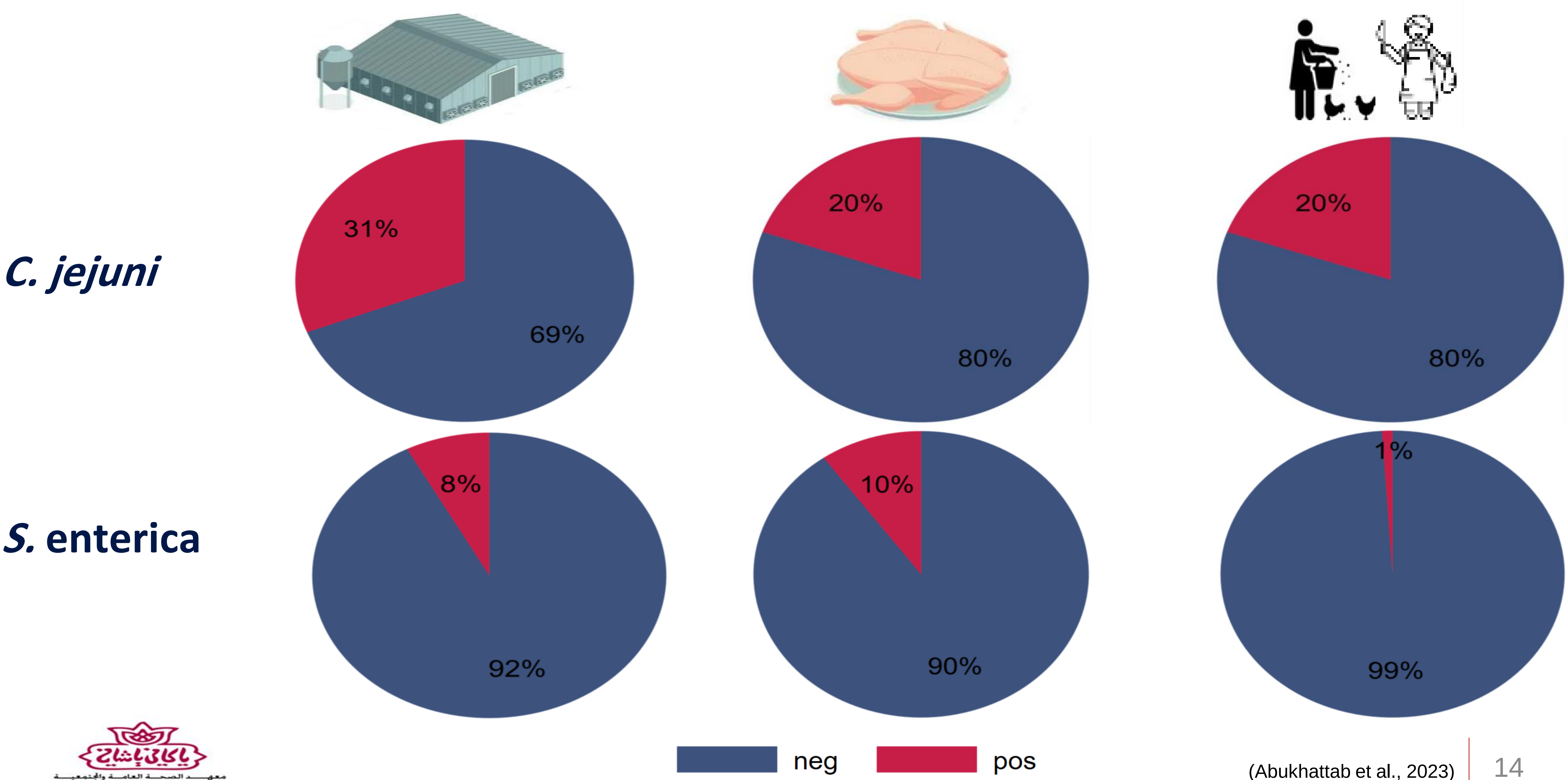
(Abukhattab et al., 2022)

Integrated surveillance–response system (iSRS)



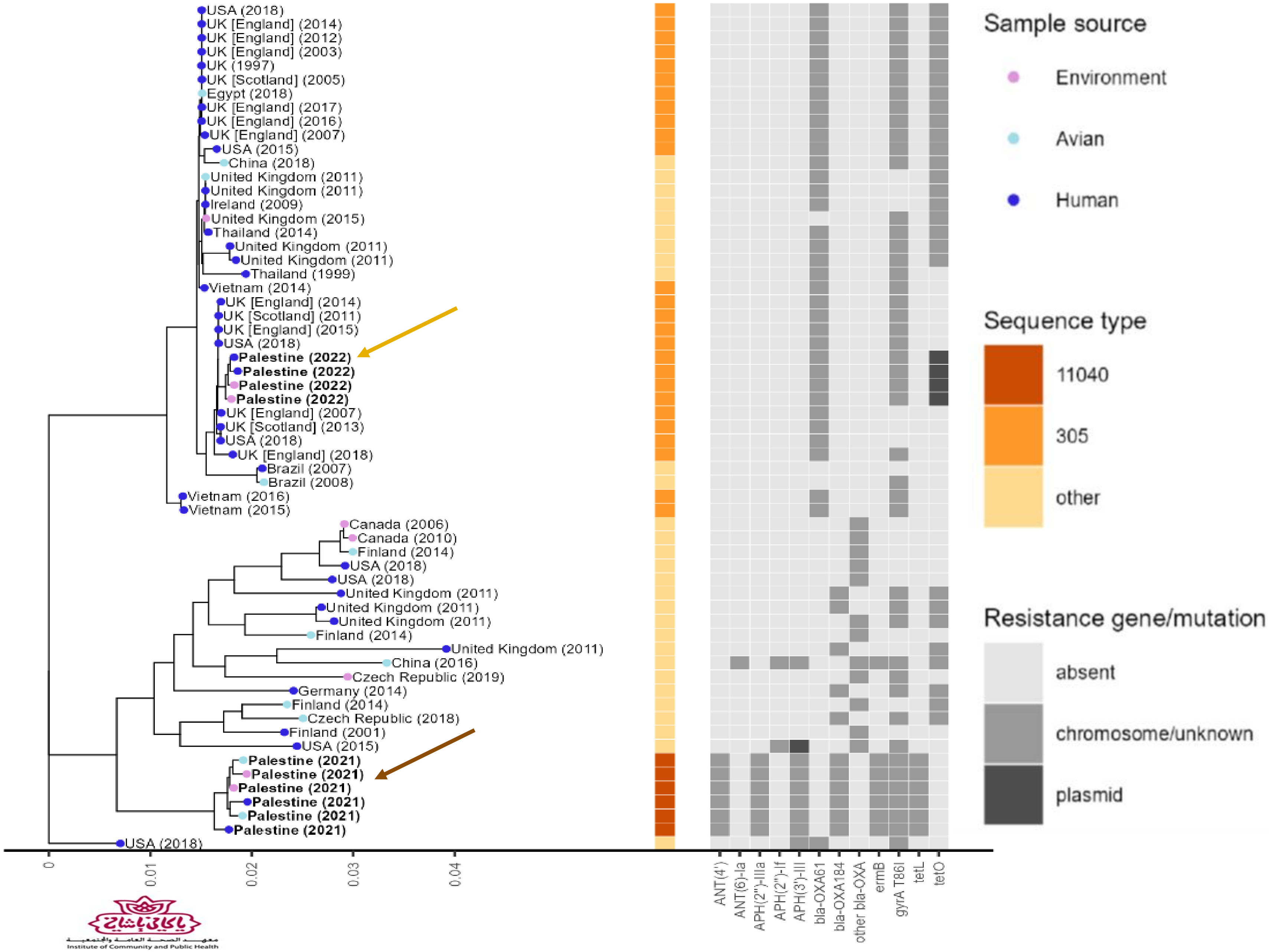
(Abukhattab et al., 2023)

Prevalence of *C. jejuni* and *Salmonella* enterica



(Abukhattab et al., 2023)

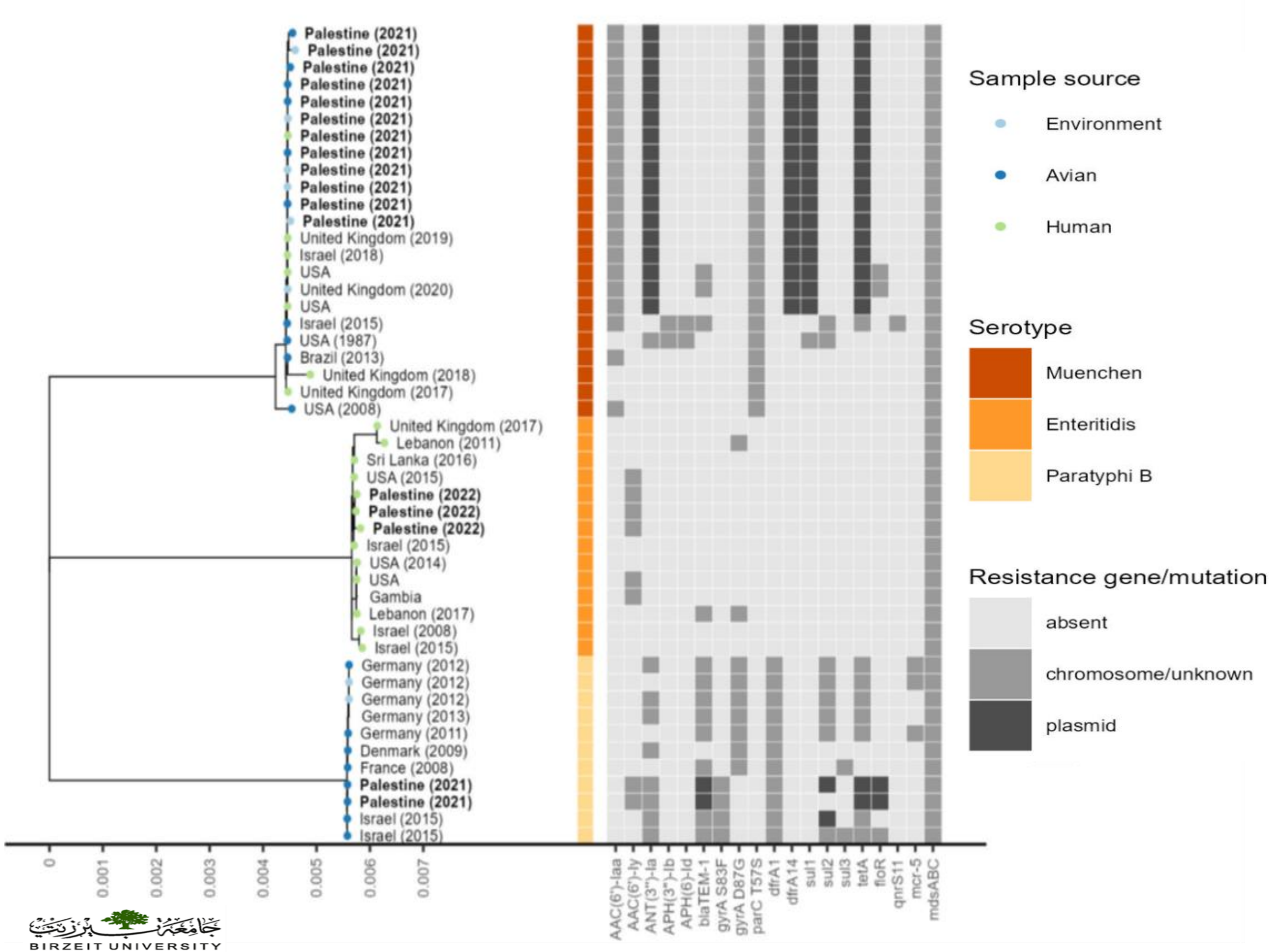
Phylogenetic analysis of *C. jejuni* isolates



- Isolates from different sources cluster together
- All isolates are *C. jejuni* subsp. *Jejuni*
- Main difference between 2021 and 2022 isolates
- 2% nucleotide difference between years

(Abukhattab et al., 2023)

Phylogenetic analysis *of S. enterica* isolates



- Isolates from different sources cluster together
- >99.96% nucleotide identity between isolates of same serotype
- Three different serotypes
- pESI in all 13 *S. enterica* serotype Muenchen

(Abukhattab et al., 2023)

AMR diffusion phenomenon

Key Challenges to conducting AMR integrated surveillance in Conflict zone :

- Logistical delays due to war
- Challenges securing sequencing services
- Financial and administrative issues
- Human resource and staffing challenges
- Restrictions on movements
- Shifts in government priorities

Ongoing Project: Antimicrobial Resistance Surveillance in West Bank: Integrated Control and Mechanisms

2023-2027

Kick-off

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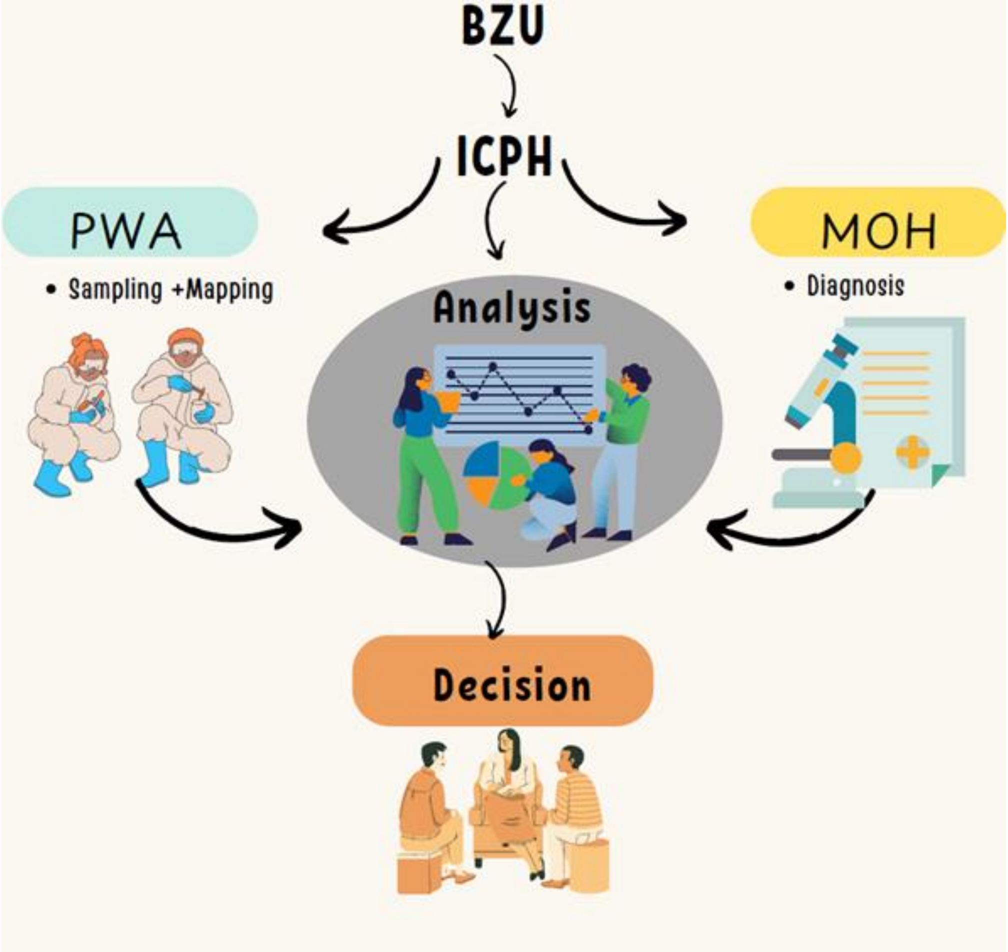
معهد الصحة العامة والمجتمعية
Institute of Community and Public Health


PWA
MoH


BZU
ICPH
PWA
• Sampling +Mapping
MOH
• Diagnosis
Analysis
Decision

Said Abukhattal

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for
AMR
Antimicrobial Resistance

Partnerships
Strengthen
Our Efforts and
Increase
Our Impact.

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