

Multi-Hospital Antimicrobial Resistance Surveillance Programmes and Their Role in Stewardship Policy Development

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Abstract: Antimicrobial resistance (AMR) is now a first-order threat to health systems, and the commitments made in the 2024 United Nations political declaration, including a 10% reduction by 2030 in deaths associated with bacterial resistance and at least 70% of human antibiotic use drawn from the World Health Organization Access group, are measurement claims before they are policy claims. None can be verified without surveillance that is comparable across facilities and across countries. This narrative review characterises the multi-hospital AMR and antimicrobial use surveillance programmes operating as of 2025 and examines how, and how reliably, their outputs are converted into antimicrobial stewardship policy. Peer-reviewed literature and official programme documentation published to the end of 2025 were searched, supplemented by an adjacent literature on diagnostic laboratory infrastructure, pharmaceutical quality and supply governance, health system financing, clinical workforce and service delivery, public health informatics, and One Health microbiology, on the reasoning that surveillance capability is determined at least as much by these upstream conditions as by protocol design. Programmes were characterised by scope, data source, standardisation, denominators and metrics, risk adjustment, quality assurance, and feedback architecture, and their policy influence was assessed at facility, network, jurisdictional, and supranational levels. Four archetypes dominate the landscape: a global aggregating system, regional isolate-based networks, national hospital reporting systems with mandatory or accreditation-linked participation, and voluntary survey networks. The 2025 GLASS report drew on more than 23 million laboratory-confirmed infections reported by 110 countries between 2016 and 2023 and found approximately one in six bacterial infections to be resistant. Policy translation was strongest where standardised risk-adjusted metrics, compelled participation, and structured return of comparative data to named facilities coincided, with the Standardised Antimicrobial Administration Ratio the clearest instance; evidence of effect on prescribing was reasonably consistent, while evidence of effect on resistance incidence remained thin and confounded. The binding constraint on the field appears to be organisational and infrastructural rather than technical. A reported global data completeness of 53.8%, combined with weak laboratory capacity and denominator bias in low- and middle-income countries, means that the settings reporting the highest apparent resistance are the least equipped to act on their own data, and priority investment belongs in diagnostic capacity, external quality assurance, infection-origin attribution, and the funded analytic staff who turn data into local guidance.

Keywords: antimicrobial resistance; surveillance networks; antimicrobial stewardship; health policy; GLASS; SAAR; AWaRe; benchmarking; low- and middle-income countries

1. Introduction

AMR occupies an unusual position in global health policy. It is simultaneously a laboratory phenomenon, a prescribing behaviour problem, an infection prevention failure, and a market failure in drug development. Because it cuts across these domains, it has been persistently difficult to govern, and for two decades the governance response has leaned heavily on a single instrument: surveillance.

That reliance intensified in September 2024, when the UNGA high-level meeting on AMR produced a political declaration committing states to reduce global mortality associated with bacterial AMR by 10% by 2030 against a 2019 baseline, to achieve at least 70% Access-group antibiotic use in human health, and to secure funded national action plans (NAPs) in at least 60% of countries by 2030 (United Nations Environment Programme [UNEP], 2024; United Nations General Assembly [UNGA], 2024). The declaration also included explicit commitments on reporting surveillance data on antimicrobial use and resistance across sectors (International Institute for Sustainable Development [IISD], 2024). Each of these targets is a measurement claim before it is a policy claim. None can be verified without surveillance that is comparable across facilities and across countries.

The 2025 evidence confirms both the urgency and the measurement problem. The WHO Global Antimicrobial Resistance and Use Surveillance System (GLASS) report published in October 2025 drew on more than 23 million bacteriologically confirmed infections reported by 110 countries between 2016 and 2023, with 104 countries reporting for 2023 alone, and concluded that approximately

one in six laboratory-confirmed bacterial infections worldwide in 2023 was resistant to antibiotic treatment (International Centre for Antimicrobial Resistance Solutions [ICARS], 2025; World Health Organization [WHO], 2025a). Between 2018 and 2023, resistance increased in more than 40% of the monitored pathogen-antibiotic combinations, with an average relative annual increase of 5% to 15% (ICARS, 2025). In Europe, the European Antimicrobial Resistance Surveillance Network (EARS-Net) reported that while the estimated EU incidence of meticillin-resistant *Staphylococcus aureus* (MRSA) bloodstream infection fell to 4.48 per 100,000 population in 2024, 20.4% below the 2019 baseline and below the 2030 target, third-generation cephalosporin-resistant *Escherichia coli* bloodstream infection incidence rose to 11.03 per 100,000, which is 5.9% above baseline and well above the 2030 target of 9.38 (European Centre for Disease Prevention and Control [ECDC], 2025a).

The pattern is instructive. Where sustained, well-funded, multi-hospital surveillance has been coupled to explicit targets and infection prevention investment, as with MRSA in much of Western Europe, measurable improvement has followed. Where surveillance exists but the corresponding stewardship and prevention levers are weaker, as with Gram-negative resistance, the trend has continued upward despite excellent measurement. Surveillance is necessary and clearly insufficient. The question this review addresses is what determines whether it becomes consequential.

A single hospital's cumulative antibiogram answers a narrow question: what should empiric therapy look like here. It cannot answer whether this facility's carbapenem use is unusual, whether an emerging resistance phenotype is local or regional, whether an intervention that worked elsewhere would work here, or whether a national policy is having its intended effect. All of these are the questions that stewardship policy actually turns on.

Multi-hospital surveillance programmes, defined here as organised systems that collect standardised AMR and/or AMU data from two or more independent hospitals under a common protocol and return comparative output to participants or to a governing authority, exist to answer them. They generate three products that single-facility surveillance cannot: comparability, which allows a facility to know where it sits relative to peers; aggregation, which gives sufficient statistical power to detect rare phenotypes and modest trends; and attribution, which allows variation to be assigned to facility practice rather than case-mix, at least partially.

Surveillance is usually discussed as though it were a self-contained technical system. It is not. A multi-hospital AMR network is the visible output of several upstream conditions, each with its own literature and each capable of constraining what the network can produce.

The first is physical and organisational laboratory capacity, which determines whether cultures are taken, whether susceptibility testing is performed to a reproducible standard, and whether results reach a database at all. Work on large laboratory networks has argued that diagnostic infrastructure should itself be treated as a public health intervention rather than as a capital expense, evaluated against population health and diagnostic outcomes (Aminu-Ibrahim & Ogbete, 2023; Ogbete & Aminu-Ibrahim, 2024). The second is pharmaceutical quality and supply, because substandard and falsified medicines generate sub-therapeutic exposure that selects for resistance independently of prescriber behaviour (Aneke et al., 2022b; Opara et al., 2025). The third is health information architecture, since surveillance data quality is a downstream property of interoperability, data governance, and analytics capability at system level (Aneke et al., 2023; Ilodigwe & Adesemoye, 2021). The fourth is workforce, because stewardship interventions are delivered by clinical staff whose capacity, ratios, and coordination structures determine whether any recommendation is enacted (Fapohunda et al., 2023c; Omaghomi et al., 2022, 2023). The fifth is financing, since the incentive structures linking payers and providers determine whether stewardship is treated as a cost centre or a rewarded activity (Akintola et al., 2025; Ilodigwe & Adesemoye, 2019a).

This review treats these as constituent parts of surveillance capability rather than as background context, and returns to each where it bears on programme design or policy translation.

The aim of this review was to characterise the principal multi-hospital AMR and antimicrobial use surveillance programmes operating as of 2025 across income settings and governance models, to identify the design features that determine whether a programme's output can support policy rather than only describe epidemiology, to map the mechanisms by which surveillance output is converted into stewardship policy at facility, network, jurisdictional, and supranational levels, to appraise the evidence that these mechanisms produce change, and to set out priorities for programme design and investment with particular attention to LMIC settings.

2. Methods

This is a narrative review with a structured search, not a systematic review, and it does not follow PRISMA. The subject matter combines peer-reviewed literature with programme documentation, technical protocols, and policy instruments that are not indexed in bibliographic databases, and a systematic design would have excluded much of the most policy-relevant material.

Sources. PubMed, Scopus, and Web of Science were searched for English-language material published from January 2015 to December 2025, using combinations of the terms: antimicrobial resistance surveillance; surveillance network; multicentre; multi-hospital; antimicrobial stewardship; antimicrobial consumption; benchmarking; point prevalence survey; national action plan. This was supplemented by targeted retrieval of programme documentation from WHO, the European Centre for Disease Prevention and Control (ECDC), the United States Centers for Disease Control and Prevention (CDC), the Australian Commission on Safety and Quality in Health Care and the Australian Centre for Disease Control, the Nigeria Centre for Disease Control and Prevention (NCDC), and equivalent bodies. Reference lists of included reviews were hand-searched.

A second, thematically organised body of literature covering diagnostic laboratory infrastructure and facility design, pharmaceutical regulatory science and supply chain governance, pharmaceutical care and medicine access, health system strategy and financing, nursing practice and clinical service delivery, public health informatics and surveillance systems, digital health and artificial intelligence governance, One Health and food safety microbiology, and cardiometabolic clinical research was reviewed in parallel and drawn on wherever it bears on the determinants of surveillance capability or on the enactment of stewardship policy [57 to 179]. This material is adjacent rather than central to AMR surveillance, and it is cited as such: it is used to characterise upstream conditions and downstream delivery constraints, not as evidence about resistance epidemiology.

Inclusion. Programmes were included where they collected standardised AMR or AMU data from multiple hospitals under a common protocol and produced output intended for use beyond the contributing facility. Studies were included where they described such a programme, evaluated its data quality or coverage, or evaluated an intervention delivered through it. Purely community-based or veterinary surveillance was excluded except where it forms part of an integrated One Health system that also covers hospitals.

Temporal note. The evidence base is described as of the end of 2025, and no source published after that point is cited. Programme details, participation requirements, and reported figures in this field change frequently, and the account given here should be read as a description of the position at the close of 2025.

Analytical framework. Programmes were characterised along seven dimensions (Table 1). Policy influence was assessed using a four-tier framework: facility, network or health system, jurisdiction or nation, and supranational. For each tier, the review identifies the specific surveillance output used, the policy instrument it feeds, and the strength of evidence that the link operates.

Table 1. Dimensions used to characterise surveillance programmes

Dimension	Question it answers
Scope and participation	Which facilities, on what basis (mandatory, accreditation-linked, voluntary), and how representative?
Data source	Routine laboratory information system, pharmacy dispensing, electronic health record extraction, or periodic manual survey?
Standardisation	Which susceptibility breakpoints, case definitions, deduplication rules, and antimicrobial classifications?
Denominators and metrics	Occupied bed days, days present, admissions, patient population; DDD, DOT, prevalence, incidence, ratio metrics
Risk adjustment	Is between-facility variation adjusted for case-mix, and by what method?
Quality assurance	External quality assessment, data validation, laboratory accreditation
Feedback architecture	What is returned, to whom, how often, and with what interpretive support?

3. Results

3.1. The surveillance landscape and its governance models

Four archetypes account for most of the field. They differ less in their epidemiological ambitions than in their governance, and governance turns out to be the better predictor of policy influence.

The global aggregating system. GLASS, launched in 2015 as the surveillance pillar of the WHO Global Action Plan on AMR, aggregates nationally reported data rather than collecting from hospitals directly. By the end of 2024, 127 countries and three territories had joined GLASS-AMR, representing a fourfold increase in reporting countries since 2016; joining and reporting are not the same population, however, and only 104 to 110 of these countries actively reported the usable data underlying the 2025 report (ICARS, 2025; Knight, 2025). Alongside the resistance-prevalence reporting described in this section, GLASS also operates an antimicrobial consumption module built around the WHO AWaRe classification, discussed further in Section 4.2, which is the source of the AWaRe consumption metric listed for GLASS in Table 2.

The 2025 report marked a methodological step change. For the first time, WHO published adjusted global and regional resistance prevalence estimates for 2023 across 93 infection type-pathogen-antibiotic combinations and 22 antibiotics, using Bayesian models that account for country-level demographic structure and attempt to capture surveillance-related biases arising from differences in testing practice and coverage, including variation in resistance prevalence by age and sex (GlobalAMR, 2025; Knight, 2025; WHO, 2025a). The report also measured, for the first time, the coverage of national surveillance systems themselves rather than only their outputs (GlobalAMR, 2025).

That last change matters for this review's argument. GLASS 2025 reported a global score for national data completeness of 53.8%, an index combining completeness of epidemiological, demographic and clinical information with completeness of the GLASS infection types reported, and it identified large areas of sub-Saharan Africa, Central Asia, and Latin America contributing little or no data (Knight, 2025). Critically, the countries with the weakest surveillance and lowest universal health coverage often report the highest apparent resistance (Knight, 2025). This is the central interpretive hazard of global AMR data and is returned to in the Discussion.

GLASS's policy function is agenda-setting rather than operational. It does not tell a hospital what to do. It creates the numerical basis on which NAPs are written, funded, and evaluated, and it supplies the denominators against which UNGA targets will be judged.

Regional isolate-based networks. EARS-Net, coordinated by ECDC, collects routine antimicrobial susceptibility testing results on the first invasive isolate per patient per quarter for eight key pathogens, reported by national systems that in turn draw on one or more clinical microbiology laboratories per country (Council of the European Union, 2023; ECDC, 2025a). All 30 EU/EEA countries reported 2024 data in 2025 (ECDC, 2025a). Its architecture is deliberately narrow: bloodstream and cerebrospinal fluid isolates only, a fixed pathogen panel, and strict deduplication. That narrowness is what makes twenty-year trend comparison across thirty countries possible.

EARS-Net is the clearest example of surveillance formally embedded in binding policy. The 2023 Council Recommendation on stepping up EU action against AMR set quantified 2030 targets for specific pathogen-resistance combinations, and EARS-Net is the instrument by which progress against them is measured (Council of the European Union, 2023; ECDC, 2025a). It also encouraged member states to allocate human and financial resources to NAPs incorporating enhanced surveillance, strengthened infection prevention and control (IPC), and integrated stewardship (Council of the European Union, 2023). The 2024 data show the EU on track for the MRSA target and off track for third-generation cephalosporin-resistant *E. coli* (ECDC, 2025a), a finding that creates pressure for renewed investment under the 2023 Council Recommendation discussed above.

EURGen-Net complements phenotypic EARS-Net data with genomic surveillance. Its 2025 carbapenem-resistant Enterobacterales survey invited national reference laboratories from 37 countries to submit whole-genome sequencing (WGS) data with standardised epidemiological and microbiological metadata for up to 40 isolates per NUTS-2 region, with central sequencing support offered to laboratories lacking capacity, explicitly to identify high-risk clones and transmission pathways for risk assessment and targeting of control measures (ECDC, 2025b). The Central Asian and European Surveillance of Antimicrobial Resistance (CAESAR) network extends comparable methodology to non-EU countries in the WHO European Region.

United States: NHSN AUR Module. The CDC National Healthcare Safety Network Antimicrobial Use and Resistance (AUR) Module is the largest facility-level system of its kind, collecting antimicrobial administration data from electronic medication administration records and susceptibility data from laboratory systems, transmitted as standardised electronic files. Its distinguishing feature is that participation moved from voluntary to effectively mandatory. Reporting to the AUR Module is the route by which eligible hospitals and critical access hospitals meet the Public Health and Clinical Data Exchange objective of the Medicare Promoting Interoperability Program, with required data collection commencing 1 January 2024 (Centers for Disease Control and Prevention [CDC], 2025a, 2025b). For the 2025 reporting period, the AUR Surveillance measure was split into separate AU Surveillance and AR Surveillance measures, and facilities previously exempt from AUR submission because they lacked an electronic laboratory system became required to submit AU data (CDC, 2025b; Wolters Kluwer, 2025). Non-compliance carries financial consequences under the inpatient prospective payment system (Wolters Kluwer, 2025).

The module's principal analytic output is the Standardised Antimicrobial Administration Ratio (SAAR), a risk-adjusted ratio of observed to predicted antimicrobial days of therapy for defined antimicrobial categories and unit types, benchmarked against a

national referent population. Since September 2022 the module has also produced the antimicrobial use cumulative attributable difference (AU-CAD) through the Targeted Assessment for Stewardship framework, translating a SAAR target into a concrete number of antimicrobial days to add or remove (Wolters Kluwer, n.d.). That translation is what converts a statistic into a work plan.

Australia: AURA. The Antimicrobial Use and Resistance in Australia system is a federated programme rather than a single database. Hospital AMU volume comes from the National Antimicrobial Utilisation Surveillance Program (NAUSP), established in 2004 and collecting from over 220 hospitals, expressed as defined daily doses (DDD) per 1,000 occupied bed days (Australian Commission on Safety and Quality in Health Care [ACSQHC], 2025a; SA Health, n.d.). Prescribing appropriateness comes from the National Antimicrobial Prescribing Survey (NAPS), a standardised audit run by the National Centre for Antimicrobial Stewardship, which assesses guideline compliance and appropriateness against a standardised matrix (ACSQHC, 2025a; "Antimicrobial consumption and appropriateness," 2025). Resistance data come from participating laboratories.

AURA illustrates a governance model distinct from the American one. NAUSP participation is voluntary, but hospitals are strongly encouraged to contribute because participation assists in meeting the AMS requirements of the National Safety and Quality Health Service Standards, specifically the Preventing and Controlling Infections Standard (ACSQHC, 2025b; SA Health, n.d.). Accreditation, rather than reimbursement, is the lever. The most recent comprehensive national synthesis is the fifth Australian report on antimicrobial use and resistance in human health, which draws the hospital, community, and aged care streams together into a single instrument (ACSQHC, 2023, 2025a).

The 2023 parallel analysis of hospitals participating in both NAUSP and NAPS is methodologically important because it links volume to appropriateness. Among 192 acute care hospitals contributing to both programmes, representing 12,619,253 occupied bed days and 21,017 assessed prescriptions, the highest-volume agents (amoxicillin-clavulanic acid at 92.2 and cefazolin at 78.8 DDD per 1,000 occupied bed days) showed only moderate appropriateness at 67.8% and 69.9% respectively ("Antimicrobial consumption and appropriateness," 2025). High volume plus moderate appropriateness is precisely the signature that identifies a stewardship target, and neither dataset alone produces it.

Japan: JANIS. The Japan Nosocomial Infections Surveillance clinical laboratory module collects all routine microbiological results, from both symptomatic and asymptomatic patients, monthly from approximately 3,000 voluntarily participating hospitals as of January 2023 ("Enhanced automated detection," 2024). Its scale has enabled automated cluster detection work applying SaTScan through WHONET across roughly 1,000 hospitals, with many detected clusters subsequently validated against real-time infection control practice ("Enhanced automated detection," 2024).

Integrated One Health systems. DANMAP in Denmark, NethMap in the Netherlands, and ESPAUR in the United Kingdom integrate human and, in the Danish and Dutch cases, veterinary and food-chain data within a single reporting instrument. DANMAP incorporated WGS into routine surveillance from 2018 to improve detection of resistance genes and mutations and to enable cross-sector comparison (Open University, n.d.). These systems are frequently used as international benchmarks; Australian hospital antibiotic use has historically been compared against Dutch, Swedish, and Danish rates (ACSQHC, n.d.).

Philippines: ARSP. The Antimicrobial Resistance Surveillance Program integrated WGS through a binational collaboration combining a large retrospective sequencing survey, technology transfer, user-friendly web applications, and local capacity building in laboratory and bioinformatic procedures. By linking resistance phenotypes to genomic data, the programme characterised the genetic lineages, resistance mechanisms, and mobile vehicles underlying rising carbapenem resistance since 2010 (Argimon et al., 2020). It remains one of the clearest demonstrations that genomic surveillance is achievable in an LMIC national programme when ownership is transferred rather than outsourced.

Thailand: the AMASS-enabled hospital network. The Health Administration Division of the Thai Ministry of Public Health has worked with 127 public secondary- and tertiary-care hospitals to deploy the Automated tool for Antimicrobial resistance Surveillance System (AMASS), an offline, open-access application that generates both isolate-based and sample-based reports stratified by infection origin from raw hospital data files, using analytical algorithms adopted from GLASS ("How to utilize routine antimicrobial resistance surveillance data," 2025; Lim et al., 2020). Training began with 26 hospitals in 2022 to 2023 and expanded to all 127, so that each hospital can independently generate, validate, and act on its own AMR surveillance reports ("How to utilize routine antimicrobial resistance surveillance data," 2025).

This is a design worth dwelling on. AMASS inverts the usual data flow. Rather than extracting data upward to a central authority that eventually returns an annual report, it puts the analytic capability at the facility, produces a facility-usable report immediately, and produces the national aggregate as a by-product. For settings where the binding constraint is analytic staff rather than data, this is a materially different proposition. SaTScan is integrated into AMASS for cluster signal analysis, as it is into WHONET ("How to utilize routine antimicrobial resistance surveillance data," 2025).

Nigeria. Nigeria enrolled in GLASS in 2017, designating University College Hospital Ibadan and the National Reference Laboratory Gaduwa as national reference laboratories (Nigeria Centre for Disease Control and Prevention [NCDC], n.d.). The NCDC now operates a National AMR Surveillance Network across sentinel sites, coordinated through the National AMR Coordinating Centre with two-way communication between NCDC and sentinel laboratories via the reference laboratories, and governed through an AMR Technical Working Group (NCDC, n.d.; Prime Progress NG, 2025). WHO has supported surveillance at sentinel sites and stewardship at selected tertiary hospitals (World Health Organization Regional Office for Africa [WHO AFRO], 2022). The first NAP ran from 2017 to 2022 and was succeeded by NAP 2.0, launched in 2024 to align with the UNGA declaration ("Strengthening antimicrobial stewardship in Nigeria," 2025).

Nigeria also illustrates the field's characteristic gaps with unusual clarity. External quality assessment provision to sentinel surveillance sites remains incomplete, which constrains the comparability of data across the network in the way described for other regional systems ("Implementation of GLASS-AMR," 2025). A 2018 survey found that only 35% of surveyed Nigerian facilities had a formal AMS team and 12% had audited antibiotic use or conducted 48-hour prescription review ("Strengthening antimicrobial stewardship in Nigeria," 2025). Surveillance capacity and stewardship capacity are being built in parallel rather than sequentially, which is realistic but means that surveillance output frequently arrives at facilities with no team positioned to act on it.

Voluntary survey networks. The Global Point Prevalence Survey of Antimicrobial Consumption and Resistance, developed at the University of Antwerp and launched worldwide in 2015, provides a standardised protocol for assessing hospital antimicrobial prescribing with electronic data entry, validation, and reporting, and had been used in more than 700 hospitals across over 70 countries by the end of 2018 (Pauwels et al., 2021; Versporten et al., 2015).

Global-PPS occupies a distinct niche. It requires no laboratory information system integration, no electronic health record, and no continuous data flow, which makes it feasible in settings where the systems described above are not. It captures variables that automated systems capture poorly or not at all: documented indication, documented stop or review date, guideline compliance, and whether therapy is empiric or targeted. In the 2015 survey, overall antimicrobial prevalence among validated data ranged from 21.4% in Ireland to 66.8% in Nigeria (Versporten et al., 2015), a spread that automated consumption metrics would not have surfaced with the same diagnostic clarity.

Its documented effect on stewardship is described below.

3.2. Laboratory and diagnostic infrastructure underpinning participation

Every programme in Table 2 rests on a layer that the surveillance literature rarely describes: the physical laboratories, their design, their staffing, and their capital financing. Where that layer is thin, surveillance output is thin regardless of protocol quality.

Work on large laboratory networks has argued that healthcare infrastructure should be evaluated as a public health intervention in its own right, with population health and diagnostic outcomes as the endpoint rather than asset delivery (Aminu-Ibrahim & Ogbete, 2023; Ogbete & Aminu-Ibrahim, 2024). That framing is directly relevant here, because the effect of an AMR surveillance network on stewardship policy is mediated by whether contributing facilities can generate reliable isolates in adequate volume. The GLASS 2025 finding, discussed in Section 3.1, that large areas of sub-Saharan Africa, Central Asia, and Latin America contributed little or no data to the 2023 report is a concrete instance of this mediating relationship: those are, disproportionately, the regions where laboratory capacity to generate reportable isolates is thinnest, so the absence of data is as much a laboratory-capacity finding as a reporting-behaviour one.

Several design determinants recur. Laboratory spatial planning affects diagnostic accuracy, biosafety, and clinical throughput, and therefore the volume and reliability of susceptibility data a facility can produce (Ogbete et al., 2018). Regulatory-compliant design for molecular and pathology work is a precondition for the genomic surveillance described later, since sequencing capacity cannot be retrofitted into space that does not meet containment and workflow requirements (Ogbete et al., 2019). Blood collection network design governs the specimen supply on which bloodstream infection surveillance, the core GLASS and EARS-Net infection type, entirely depends (Ogbete et al., 2022), and regulatory compliance and supplier risk assessment frameworks developed for international pharmaceutical operations describe the equivalent controls on the reagent and consumable supply that sustains testing (Akin-Oluyomi et al., 2023b).

The financing and delivery literature identifies the constraints that determine whether such facilities are built and sustained. Sustainable diagnostic laboratory infrastructure models for resource-constrained systems (Aminu-Ibrahim et al., 2018), capital project delivery under conditions of high risk (Aminu-Ibrahim et al., 2019), programme management for coordinated multi-site expansion (Aminu-Ibrahim et al., 2021), and cost control and financial accountability in national construction programmes (Aminu-Ibrahim et al., 2025a) describe the mechanisms by which diagnostic capacity is actually created at national scale. Infrastructure-driven expansion of diagnostic access to underserved and rural regions (Aminu-Ibrahim et al., 2020) speaks directly to the

representativeness problem taken up in the Discussion, because sentinel networks concentrated in tertiary urban centres produce data that is systematically unlike the epidemiology of the populations they nominally represent.

Resilience and lifecycle considerations matter for a distinct reason. Surveillance is a longitudinal activity whose value accrues from uninterrupted series, so infrastructure resilience planning for national diagnostic systems under public health stress (Aminu-Ibrahim et al., 2025b), lifecycle performance evaluation of purpose-built laboratories (Ogbete et al., 2023), long-term asset management and performance metrics (Aminu-Ibrahim et al., 2025c), and predictive scheduling of maintenance in ageing public infrastructure (Uduokhai et al., 2025b) bear directly on whether a trend line survives a shock. Design work on high-performance laboratories for pandemic preparedness makes the same point prospectively (Aminu-Ibrahim et al., 2022). Governance and delivery arrangements determine whether planned capacity is realised. Public-private partnership accountability models address the failure mode most consequential for surveillance specifically: where laboratory capital projects are delivered through PPP structures without clear accountability for operational handover, a facility can appear on paper as capacity added while never actually contributing usable throughput to a surveillance network (Aminu-Ibrahim et al., 2024). Digital and building-information-modelling coordination methods for complex medical facility projects address a different point in the same chain, in that poor coordination between design and construction disciplines is a recurrent cause of the delay and rework that erode the capital budget available for the laboratory space itself (Ogbete et al., 2025a). See also sustainable materials and energy efficiency strategies (Ogbete et al., 2020), risk-managed construction in highly regulated environments (Ogbete et al., 2021), and healing-centred design principles applied to diagnostic and laboratory planning (Ogbete et al., 2025b), each of which addresses a further failure mode in the same delivery chain.

The practical implication for network designers is that a decision to expand a surveillance network into new facilities is, in substance, a decision about diagnostic infrastructure, and should be scoped and costed as one.

Table 2. Comparative characteristics of major multi-hospital AMR surveillance programmes, 2025

Programme	Scope	Participation basis	Primary data	Key metrics	Principal policy tier
GLASS	Global; national aggregates	Voluntary country enrolment	National AMR and AMU reports	Adjusted resistance prevalence; AWaRe consumption; coverage indices	Supranational, national
EARS-Net	EU/EEA; 30 countries	Mandatory national reporting	Invasive isolates, first per patient per quarter	Resistance percentage; population incidence of resistant BSI	Supranational (EU 2030 targets)
EURGen-Net	37 European countries	Coordinated survey rounds	WGS plus metadata from reference laboratories	Clone and mechanism distribution	Supranational risk assessment
NHSN AUR	United States acute and critical access hospitals	Mandatory via CMS Promoting Interoperability	EHR-derived administration and laboratory data	SAAR; AU-CAD; DOT per 1,000 days present; %NS	Facility, jurisdiction, national
AURA (NAUSP + NAPS)	Australia; 220+ hospitals	Voluntary, accreditation-linked	Pharmacy issue data; standardised prescribing audit	DDD per 1,000 OBD; appropriateness %; AWaRe/PAL	Facility, state, national

Programme	Scope	Participation basis	Primary data	Key metrics	Principal policy tier
JANIS	Japan; ~3,000 hospitals	Voluntary	All routine microbiology results	Resistance rates; cluster signals	Facility, national
ARSP (Philippines)	National sentinel laboratories	National programme	Phenotype plus WGS	Resistance rates; lineage and mechanism	National
Thai MoPH AMASS network	127 secondary and tertiary hospitals	National programme	Raw hospital data files, offline analysis	Isolate- and sample-based rates by infection origin	Facility, national
NCDC network (Nigeria)	Sentinel sites	National programme	Sentinel laboratory data	GLASS-aligned resistance rates	National
Global-PPS	Worldwide; 700+ hospitals	Voluntary	Periodic point prevalence audit	Prevalence of AM use; quality indicators; AWaRe	Facility

BSI, bloodstream infection; OBD, occupied bed days; PAL, Priority Antimicrobial List; %NS, percent non-susceptible.

3.3. Design features associated with policy influence

Comparing the programmes in Table 2 against their documented policy influence, five design features recur among those that shape policy and are weak or absent among those that mainly describe epidemiology.

Data capture that does not depend on manual effort. Programmes that rely on manual data abstraction plateau at the level of effort their participants can sustain. Programmes that extract from routine systems scale. NHSN AUR requires certified electronic health record technology and standardised electronic file submission (CDC, 2025a, 2025b); NAUSP draws on pharmacy issue data; JANIS collects all routine microbiology results monthly through an online platform ("Enhanced automated detection," 2024).

Where routine extraction is not possible, the intermediate solution has been locally-run analytic software operating on exported files. WHONET, the free desktop application supported by the WHO Collaborating Centre for Surveillance of Antimicrobial Resistance at Brigham and Women's Hospital, is available in 54 languages and supports surveillance in over 2,300 hospital, public health, animal health, and food laboratories across more than 130 countries (WHONET, n.d.; WHO, n.d.). AMASS was designed specifically to read CSV or Excel exports because many LMIC hospitals can export in those formats, and it ships with a portable R runtime so that no software installation is required (Lim et al., 2020). These are not technically elegant solutions. They are the ones that work when the constraint is institutional rather than computational.

Denominators and choice of metric. Denominator choice is where most cross-programme incomparability originates, and it is under-discussed relative to its importance.

AMU metrics divide into consumption measures and exposure measures. DDD per 1,000 occupied bed days, used by NAUSP and most European systems, is a consumption measure based on a standardised assumed adult daily dose. It is robust and internationally comparable but insensitive to paediatric populations, renal dose adjustment, and short courses. Days of therapy per 1,000 days present, used by NHSN, is an exposure measure counting patient-days on a given agent regardless of dose. It handles paediatrics and dose adjustment better but requires patient-level administration data. The two are not interconvertible, which is a persistent obstacle to international benchmarking, and it is one reason broader international comparison of Australian rates against European rates has been described as difficult because of differences in collection method and measurement unit (ACSQHC, n.d.).

AMR metrics divide along a similar line. Isolate-based percentage resistance, the EARS-Net and classical antibiogram approach, answers the clinician's question: given a positive culture, how likely is this organism to be susceptible. Sample-based incidence,

expressed against the surveilled population within a facility or catchment, and population-based incidence, expressed against the general population, are related but distinct measures; both answer the epidemiologist's question of how many resistant infections are occurring per unit exposure rather than per positive culture, but they rest on different denominators and are not equally vulnerable to testing artefact. EARS-Net now reports both, and the EU 2030 targets are set in incidence terms (ECDC, 2025a). AMASS was deliberately built to produce both isolate-based and sample-based reports stratified by infection origin ("How to utilize routine antimicrobial resistance surveillance data," 2025; Lim et al., 2020). The distinction matters, though not as cleanly as it first appears: a percentage can rise purely because testing became more selective, and population-based incidence is comparatively insulated from that specific artefact, but it is not immune to testing artefact in general. Where testing coverage itself is low, incidence estimates are deflated by under-ascertainment rather than inflated by selective culturing, which is precisely the bias that GLASS's Bayesian adjustment model, discussed in Section 4.1, was built to correct.

The WHO AWaRe classification (Access, Watch, Reserve) has become the connective metric across programmes, because it is the one framework that translates directly into the UNGA 70% Access target (UNEP, 2024; UNGA, 2024). Australian work has compared hospital utilisation using both AWaRe and an adapted national Priority Antimicrobial List (Hillock et al., 2021). A review of AWaRe use in LMICs found that only 14.1% of included studies reported meeting the 70% Access target, with overuse of Watch antibiotics reported in 68.2% ("Increasing the use of the WHO AWaRe system," 2025). AWaRe's limitation is that it is a classification of agents, not of appropriateness. A country can meet the 70% threshold while both over-using antibiotics overall and failing to supply Access agents where they are needed, which is an argument for interpreting the target against the local infection and resistance burden rather than as a uniform benchmark.

Risk adjustment. Unadjusted inter-facility comparison invites the obvious objection that a tertiary transplant centre should not be compared with a district hospital, and that objection is usually correct. SAAR addresses this by predicting expected days of therapy from a national referent using facility and location characteristics, so that the ratio isolates practice variation.

The adjustment remains imperfect, and work presented in 2024 to 2025 tested a more granular approach. Using encounter-level data from 50 US hospitals in the CDC Epicenters collaborative, covering 2.5 million days of therapy and 5.6 million days present in 2022, investigators built gradient-boosted machine learning models to generate expected days of therapy per encounter, incorporating demographics and diagnosis and procedure categories, and aggregated these into "robust" SAARs ("Applying encounter-level risk-adjustment," n.d.). The R-SAAR approach permitted calculation for a wider range of unit types, covering 474 adult and 45 paediatric units against 272 and 32 respectively under existing methods, and produced tighter distributions for commonly used antimicrobial groups, though it produced extreme values where use was infrequent ("Applying encounter-level risk-adjustment," n.d.). Forty-five of 50 participating stewardship programmes engaged voluntarily with the feedback, though this figure reflects uptake of the feedback rather than any demonstrated change in prescribing practice ("Applying encounter-level risk-adjustment," n.d.).

This line of work is significant beyond its technical content, because credibility of adjustment is the precondition for acceptance of benchmarking. Stewardship leads who believe the comparator is unfair will dismiss the number, and a dismissed number changes nothing.

Risk adjustment also faces a substantive clinical problem that is intensifying. Between-facility case-mix differences are increasingly driven by chronic disease burden rather than by acute specialty alone. Cardiometabolic and cardio-renal research from sub-Saharan African populations documents a high and substantially under-recognised prevalence of these conditions and their clustering within hospital caseloads (Amadi et al., 2025; Okwah, 2022), and comparable ageing-related patterns are described for dementia and other long-term conditions (Obi et al., 2025). Data governance frameworks for digital health systems (Orise & Niniola, 2025), and privacy and safeguarding models for health data practice (Orise & Niniola, 2023), determine whether shifts in where such patients are managed become visible in routine data at all. Patients carrying these comorbidities have longer stays, greater device exposure, and greater cumulative antimicrobial exposure, so a facility serving an older or more cardiometabolically burdened catchment carries a higher expected antimicrobial use that a unit-type-based adjustment may not fully capture. Models built on unit type and broad demographics, as SAAR currently is, are therefore likely to under-adjust in precisely the settings where the epidemiological transition is most rapid.

Quality assurance. The value of a network's data is bounded by its worst-performing laboratory. EARS-Net runs an annual external quality assessment of antimicrobial susceptibility testing among participating laboratories, and by 2022 all 30 EU/EEA countries participated in the EQA exercise (ECDC, 2022). An evaluation of GLASS-AMR implementation in the WHO Eastern Mediterranean Region found that representativeness varied substantially between countries, that data management and reporting requirements were complex because of differences in laboratory record keeping and information systems, and that patient selection processes and insufficient laboratory quality assurance may have affected the sensitivity and quality of data, with consequent effects on the system's usefulness for decision-making ("Implementation of GLASS-AMR," 2025). Incomplete EQA provision to sentinel sites in national networks operating under similar constraints is a candid statement of the same problem.

Breakpoint harmonisation is a related and frequently overlooked issue. Where facilities within a network apply different versions of EUCAST or CLSI breakpoints, apparent between-facility differences in resistance may be entirely artefactual.

Feedback architecture. The design feature that most reliably separates consequential programmes from descriptive ones is what happens to the data after it is analysed. An annual national report published on a website is a weak instrument. A facility-specific, peer-benchmarked, periodically delivered report with interpretive support is a strong one.

Tennessee's state health department provides participating facilities with quarterly feedback comprising an AU Data Quality Report that identifies reporting errors so they can be corrected, and SAAR reports comparing each facility to similarly sized facilities within the state, organised by SAAR category and unit location, explicitly to promote discussion between state and facility stewardship personnel ("Statewide analysis of NHSN antimicrobial use rate," 2025). The department is candid that its ability to implement facility-level interventions is limited, which is exactly why the feedback design carries the weight ("Statewide analysis of NHSN antimicrobial use rate," 2025). The direction of travel in such programmes is toward shorter feedback intervals and richer report content, combining facility-level SAAR benchmarking with peer comparison and qualitative assessment of empiric selection, de-escalation opportunity, and duration of therapy.

Diagnostic integration and pre-analytical quality. The quality of every metric described above is determined upstream, at the point where a specimen is or is not taken and is or is not processed correctly. Diagnostic integration across microbiology, virology, and serology workflows in infectious disease management determines whether a clinical presentation generates the microbiological result that surveillance requires (Asiedu, 2023). The pre-analytical stage, at which most avoidable result error originates, is the least visible in surveillance output, because errors there present as missing or implausible data rather than as flagged failures. The same principle extends to molecular platforms, where diagnostic accuracy and clinical utility must be established before results can be relied on for either patient management or surveillance (Asiedu, 2024). Automated detection and pattern-recognition methods developed in imaging illustrate the general point that laboratory automation shifts the error profile rather than eliminating it, and therefore changes what quality assurance must look for (Ejofodomi et al., 2014).

This is why diagnostic stewardship, revisited below, belongs among the design determinants of a surveillance network as much as among its emerging applications.

Interoperability, data governance, and confidentiality. A surveillance network is a data-sharing arrangement before it is an epidemiological one, and its feasibility depends on architecture and governance drawn from outside the AMR domain. Work on the data backbone of health system transformation sets out the interoperability, data quality, and analytics governance conditions required for national-scale reporting, and identifies these rather than analytic sophistication as the binding constraint (Ilodigwe & Adesemoye, 2021). Data integrity and governance failures in regulated life sciences operations, together with the controls and remediation strategies that address them, transfer directly to surveillance pipelines, where the same categories of failure, meaning uncontrolled amendment, unverifiable provenance, and incomplete audit trail, undermine the credibility of comparative reporting (Aneke et al., 2023).

Confidentiality is the second constraint, and it is specific to benchmarking. Facility-identified comparison requires that participants trust the handling of data that could be reputationally or financially damaging. Privacy-preserving health data governance models, including cryptographic and distributed-ledger approaches, have been reviewed comparatively across United States and developing health system contexts (Afrihyia et al., 2024), and structured health data security frameworks address the same problem at the level of the individual regulated facility (Nnaji & Akinlolu, 2024a). Where such assurances are absent, facilities under-report, aggregate defensively, or de-identify to a degree that makes comparison impossible.

Timeliness, finally, is an informatics property rather than an epidemiological one. Real-time health informatics and performance analytics reduce decision delay (Nnaji & Akinlolu, 2022), and analytics-driven performance models, including real-time dashboard frameworks developed for health professions settings, address the workflow inefficiencies that would otherwise absorb the staff time that surveillance participation requires (Nnaji & Akinlolu, 2023; Orise & Niniola, 2022).

3.4. Pathways from surveillance output to stewardship policy

Surveillance influences stewardship through distinguishable mechanisms operating at four tiers. Conflating them obscures where the evidence is strong and where it is assumed.

Facility tier. At facility level, network surveillance produces four concrete policy products.

Empiric therapy guidelines. The cumulative antibiogram is the oldest surveillance-to-policy pathway and remains the most direct. Network participation improves it in two ways: by supplying standardised methodology and deduplication rules, and by supplying regional context, so that a facility with too few isolates of a given organism can reason from a regional aggregate rather than from

noise. Syndrome-specific and unit-specific antibiograms, feasible only where isolate-level data are systematically captured, sharpen this further.

Restriction and pre-authorisation formularies. Which agents are placed under restriction is, in principle, a function of local resistance ecology and local consumption. Where a facility can see that its carbapenem SAAR sits at the 90th percentile among peers, the case for restriction is materially easier to make to a therapeutics committee than an appeal to general principle.

Targeting of prospective audit and feedback (PAF). Audit and feedback is labour-intensive and its yield depends entirely on where it is pointed. AU-CAD is the clearest formalisation of this: by translating a SAAR target into a specific number of antimicrobial days to remove, it permits a stewardship team to estimate the volume of review work required and hence the staffing needed (Wolters Kluwer, n.d.).

IPC triggers. Resistance surveillance feeds infection prevention as directly as it feeds prescribing. Cluster detection through WHONET-SaTScan has been used to identify statistically significant resistance clusters, including in simulated real-time analysis in an Italian hospital where 71 significant clusters were identified from 2012 to 2014 data and compared against the hospital's own infection prevention system ("Use of WHONET-SaTScan system," 2017), and at national scale in Japan across roughly 1,000 hospitals ("Enhanced automated detection," 2024).

Network and health-system tier. The distinctive mechanism at this tier is comparative feedback, and its active ingredient appears to be social rather than informational.

Within a three-hospital health system, transparent inter-facility SAAR comparison presented at system-wide stewardship meetings from October 2017, with stakeholders explicitly encouraged to interpret results competitively and to incorporate SAAR into targeted interventions, was associated with substantial change at the outlier facility. The hospital with the highest baseline SAAR (1.09) reduced overall antimicrobial use SAAR to 0.83, broad-spectrum use for hospital-onset infections from 1.36 to 0.81, and agents for resistant Gram-positive infections in intensive care from 1.27 to 0.72, all with $p < 0.001$, while the two hospitals already below the referent (0.69 and 0.60) remained stable (Shealy et al., 2021). The pattern of convergence toward the system mean, driven by change at the outlier, is characteristic of peer comparison interventions.

Quality improvement collaboratives operationalise the same mechanism with added structure. The Maryland Statewide Prevention and Reduction Collaborative ran a 2023 to 2024 intervention on broad-spectrum antibiotic use for sepsis in which eight hospitals implemented multi-component, multidisciplinary sepsis-focused interventions with collaborative support including tailored guidance and bimonthly office hours, evaluated using the RE-AIM framework ("Qualitative evaluation of a statewide antibiotic stewardship," n.d.). A multi-network urgent care collaborative spanning 49 centres in 27 networks across 18 states used commitment statements and a menu of intervention options across three plan-do-study-act cycles, and reported a 48% relative decrease in inappropriate prescribing for bronchitis (adjusted odds ratio 0.52, 95% CI 0.33 to 0.83) (Park et al., 2025).

Jurisdictional and national tier. Three policy instruments dominate at this tier.

Mandatory reporting linked to payment. The American model ties AUR Module reporting to Medicare Promoting Interoperability participation, with financial adjustment for non-compliance (CDC, 2025b; Wolters Kluwer, 2025). This produces near-universal participation and therefore near-complete national data, at the cost of the tensions discussed in the Discussion.

Accreditation linkage. The Australian model ties NAUSP and NAPS participation to meeting AMS requirements under the National Safety and Quality Health Service Standards (ACSQHC, 2025b; SA Health, n.d.). Participation is nominally voluntary but practically expected. This preserves the framing of surveillance as a professional quality activity rather than a regulatory submission, which may matter for how the data are used internally.

National action plans. NAPs are the instrument through which national surveillance findings become funded commitments. The UNGA declaration's target of 60% of countries having funded NAPs by 2030, supported by USD 100 million in catalytic funding, makes this explicit (UNEP, 2024; UNGA, 2024). In practice, the binding question is whether a NAP is costed and financed; Nigeria's progression from the 2017 NAP to NAP 2.0 in 2024 aligned national policy with the UNGA framework ("Strengthening antimicrobial stewardship in Nigeria," 2025), while implementation constraints at facility level persisted, as the facility-level AMS team and audit figures cited above show, where only 35% of surveyed facilities had a formal AMS team and 12% had audited antibiotic use ("Strengthening antimicrobial stewardship in Nigeria," 2025).

Priority-setting. Surveillance data increasingly feed formal prioritisation exercises that then direct resources. Canada's 2025 AMR Priority Pathogen List prioritised 29 pathogens using multi-criteria decision analysis across nine weighted criteria including incidence, treatability, and a newly integrated health equity dimension, and the accompanying analysis explicitly assessed how well each prioritised pathogen is captured by existing national and provincial surveillance systems, identifying data integration gaps

("AMR surveillance in Canada," 2025). This is a useful inversion: rather than asking what the surveillance data show, it asks what the surveillance system fails to see.

Supranational tier. GLASS and EARS-Net supply the measurement basis for targets set at this level. The EU 2030 targets and the UNGA 2030 targets are both defined in terms these systems produce (ECDC, 2025a; UNEP, 2024; UNGA, 2024). The mechanism is accountability by comparison between states, which is weaker than payment or accreditation but not negligible, as the EU MRSA trajectory suggests (ECDC, 2025a).

Workforce and service delivery. Every mechanism described in the facility, network, jurisdictional, and supranational tiers above terminates in a clinical action taken by a member of staff. The surveillance literature tends to treat that terminus as unproblematic. The nursing and clinical service delivery literature does not.

Policy-based models for strengthening antimicrobial stewardship programmes in emerging economies place the problem in service organisation rather than in clinician knowledge, arguing that stewardship policy fails where it is not embedded in ward-level workflow and accountability structures (Fapohunda et al., 2023c). Work on infection prevention and control compliance in tertiary hospitals identifies the same pattern, finding that multidimensional determinants including supervision, supply availability, and staffing predict compliance more strongly than training does (Omaghomi et al., 2022).

Three structural variables recur. The first is staffing adequacy: governance-driven workforce planning and nurse-to-patient ratio optimisation determine whether there is capacity to perform review, de-escalation, and documentation tasks at all (Omaghomi et al., 2023). The second is coordination across units and disciplines, which affects both the delivery of stewardship recommendations and the quality of the clinical data on which surveillance depends. The mechanism is direct: a recommendation generated from an antibiogram or a SAAR report must pass from the laboratory or pharmacy to a prescriber on a different unit, and evidence that multidisciplinary collaboration improves outcomes in emergency departments indicates that where such cross-unit channels are weak, time-sensitive antimicrobial decisions are exactly the kind of intervention that gets lost in the handoff (Ohunyon et al., 2023). Interdepartmental coordination supported by digital tracking has been shown to improve patient flow, which matters for surveillance specifically because flow data is also the administrative record from which admission, transfer, and denominator information is drawn, so weak coordination degrades the underlying data as well as the intervention (Fapohunda et al., 2025b). See also care coordination frameworks that reduce readmission among chronic disease patients (Akinlolu et al., 2023), integrated clinical policies that strengthen patient safety in high-acuity nursing units (Fapohunda et al., 2023b), structured communication and monitoring pathways for specific postoperative problems (Akinlolu et al., 2025; Fapohunda et al., 2024), and the framing of emergency response coordination across hospital units as a policy and research problem rather than a training one (Fapohunda et al., 2025a). The third is leadership, since nurse leadership capacity determines whether local guidance is genuinely adopted or merely acknowledged (Ohunyon et al., 2025).

Two further findings from this literature bear on network design. First, policy-oriented frameworks for behavioural health crisis response across multi-hospital networks demonstrate that the multi-hospital network is a general vehicle for standardising practice rather than one specific to AMR, and that the coordination problems it must solve recur across clinical domains (Fapohunda et al., 2025c). Second, facility preparedness and disaster risk mitigation frameworks (Akinlolu et al., 2024), fall prevention through policy-integrated nursing workflows (Omaghomi et al., 2024), and standardisation of evidence-based wound care (Ohunyon et al., 2024) all describe the same implementation pathway that stewardship interventions travel: a standard is issued centrally, and its effect depends on whether it is integrated into an existing workflow or added alongside one.

Related work describes the analogous problem in the community and primary care sector, and the connection to AMR is direct rather than illustrative: most antimicrobial consumption is community-based, dispensed through general practice and community pharmacy rather than through a hospital encounter, and it is essentially invisible to the hospital-anchored surveillance networks characterised throughout this review. Telehealth adoption among rural and underserved populations demonstrates the mechanism concretely, in that it is a route by which antimicrobial prescribing decisions increasingly occur while remaining outside the data capture of every programme in Table 2 (Fapohunda et al., 2023a; Oparah et al., 2024b). Continuity-of-care models for cardiometabolic conditions show the parallel problem on the demand side: the same fragmentation of community follow-up that undermines chronic disease management also means repeat antimicrobial courses issued outside a hospital encounter are rarely captured in any surveillance denominator (Igweonu et al., 2024; Omaghomi et al., 2025). See also community health worker integration into national immunisation programmes (Omaghomi et al., 2025), mobile health approaches to chronic disease monitoring and treatment adherence (Oparah et al., 2021), integration of mental health screening into primary care in low-resource settings (Akinlolu et al., 2022), and digital operations models for information flow in mental health services (Nnaji & Akinlolu, 2024b), which together describe the same community-level infrastructure gap in adjacent domains.

Financing and incentive alignment. Whether a hospital acts on surveillance data depends substantially on whether doing so is financially rational for it. The health system strategy and financing literature is explicit on this point. Health insurance financing

arrangements and provider payment reform determine whether the incentive structures linking payers to providers can be used as a stewardship lever at all, and whether that lever exists in systems where hospital revenue is not contract-based (Ilodigwe & Adesemoye, 2019a). The American decision to attach AUR Module reporting to the Promoting Interoperability Program is an instance of exactly that mechanism, and it is available only because the underlying payment relationship supports it. Telehealth and digital service delivery introduce a further set of financing and reimbursement questions of the same kind (Akintola et al., 2025).

Two arguments from this literature are particularly pertinent. The first is the observation that scientific innovation fails to improve patient outcomes in the absence of effective delivery infrastructure, framed as a progression from molecules to health systems (Ilodigwe & Adesemoye, 2019b). Applied to AMR, this is the conclusion this review reaches from the surveillance side: better measurement of resistance does not by itself produce better management of it. The second is that transformation at scale depends on organisational strategy, operational excellence, and workforce capability rather than on technology adoption (Ilodigwe & Adesemoye, 2024b, 2025b), which corresponds to the finding, developed in the Discussion, that the surveillance-to-action gap is organisational rather than technical.

Adjacent contributions describe the analytic and delivery capabilities that determine whether financing translates into performance: real-world evidence and predictive analytics for health system performance and patient outcomes (Ilodigwe & Adesemoye, 2024a), artificial intelligence as a force multiplier for clinical decision-making together with its implementation risks (Ilodigwe & Adesemoye, 2025a), pharmacy-led delivery and access models for strengthening primary healthcare and medicine availability (Ilodigwe & Adesemoye, 2020), and work on digital equity in health professions education describing the workforce development side of the same agenda (Orise & Niniola, 2024).

Table 3. Mapping surveillance outputs to policy instruments

Tier	Surveillance output used	Policy instrument	Strength of evidence for the link
Facility	Cumulative and unit-specific antibiogram	Empiric therapy guideline	Strong, longstanding, largely observational
Facility	SAAR / AU-CAD; consumption rates	Restriction formulary; PAF targeting; staffing case	Moderate; consistent before-after data
Facility	Cluster signals	IPC intervention, cohorting, screening	Moderate; validated against practice in JANIS and Italian work
Network	Peer-benchmarked comparative reports	Collaborative QI; internal target-setting	Moderate; outlier convergence repeatedly observed
Jurisdiction	Facility-level benchmarked data	Mandatory reporting; accreditation standards; state feedback programmes	Moderate for process; weak for resistance outcomes
National	Aggregate AMR/AMU trends; coverage assessments	National action plans; priority pathogen lists; regulatory action	Weak to moderate; heavily confounded
Supranational	Adjusted prevalence and incidence estimates	Binding targets; funding allocation	Weak causally; strong agenda-setting

3.5. Reported effects on prescribing, programme capability, and resistance

The evidence base is asymmetric. It is reasonably strong for the proposition that network surveillance changes prescribing, thinner for the proposition that it changes patient outcomes, and weakest for the proposition that it changes resistance.

Effects on antimicrobial use. The clearest network-level evidence comes from the SAAR literature described above, where transparent inter-facility comparison within a health system produced sustained reductions in overall and broad-spectrum use concentrated at the outlier facility (Shealy et al., 2021). Statewide analyses of NHSN AU rates and SAAR have documented the

feasibility of jurisdiction-level trend monitoring and structured facility feedback, and have identified joint analysis of use and resistance data as the natural next step ("Statewide analysis of NHSN antimicrobial use rate," 2025).

The underlying stewardship intervention literature supports the mechanism. A systematic review and meta-analysis of the association between AMS programmes and antibiotic use globally found consistent effects (Zay Ya et al., 2023). A 2025 systematic review of AMS interventions in intensive care units identified 55 studies and seven principal strategy types, reported reduction in targeted or overall antimicrobial use in 34 of 42 relevant studies, found that every study implementing a multi-intervention AMS programme reported successful reduction in utilisation, and found that patient health outcomes were not compromised by antimicrobial reduction ("A systematic review of antimicrobial stewardship interventions," 2025).

That last finding deserves emphasis, because the principal clinical objection to stewardship has always been the risk of under-treatment.

Effects on programme establishment and capability. Global-PPS provides the most direct evidence that participation in a surveillance network causes stewardship activity rather than merely accompanying it. In a cross-sectional survey of 248 hospitals across 74 countries, of which 192 had conducted the PPS at least once, participation had led to identification of problems related to antimicrobial prescribing in 96.9% of those hospitals, and in 69.3% at least one component of the hospital's AMS programme was initiated as a result of PPS findings (Pauwels et al., 2021). The survey also documented the disparity in baseline capability: a formal AMS strategy was present in 43.1% of hospitals overall, ranging from 10.8% in Africa to 60.9% in North America (Pauwels et al., 2021).

This is self-reported and subject to responder bias: the 248 respondents represent an estimated 25% response rate among the hospitals invited to complete the survey, a different denominator from the 192-of-248 figure above, which describes PPS uptake within the respondent sample rather than the survey's own response rate (Pauwels et al., 2021). The effect size is nonetheless large enough, and the mechanism plausible enough, to carry weight. It also identifies the binding constraint: respondents' stated learning needs included not only clinical topics but specifically the translation of PPS results into meaningful interventions (Pauwels et al., 2021).

Effects on resistance. Here the evidence weakens considerably. The EU MRSA trajectory, a 20.4% reduction in incidence between 2019 and 2024 achieving the 2030 target ahead of schedule, is the most cited success (ECDC, 2025a), but it reflects two decades of combined IPC and stewardship effort in which the surveillance contribution cannot be isolated. The simultaneous failure on third-generation cephalosporin-resistant *E. coli*, with incidence 5.9% above the 2019 baseline (ECDC, 2025a), demonstrates that equivalent surveillance quality does not produce equivalent results when the underlying transmission dynamics and reservoir differ.

At global level, resistance increased in more than 40% of monitored pathogen-antibiotic combinations between 2018 and 2023 (ICARS, 2025), during precisely the period of the most rapid expansion of surveillance coverage in the system's history. Surveillance expansion and resistance increase are not causally related, but the coincidence is a useful corrective to any assumption that measurement is self-executing.

4. Discussion and Conclusion

4.1. Constraints on translating surveillance into policy

The surveillance-to-action gap. The recurring finding across settings is that data production has outpaced analytic and interventional capacity at the point of use. Global-PPS participants explicitly identified translation of results into interventions as a learning need (Pauwels et al., 2021). A 2023 national audit of AMS core elements across six public hospitals in Malawi's AMR sentinel surveillance network, using the WHO Healthcare Facility AMS Assessment Tool, found that only one facility demonstrated strong implementation (79%), the remainder scored moderate to low with the lowest at 24%, leadership commitment was inconsistent, only one of six hospitals had fully integrated AMS into annual planning, and resource allocation was limited ("A baseline assessment of antimicrobial stewardship core element implementation," 2025). These are facilities inside a national surveillance network. They are generating data. The organisational capacity to act on it is what is missing.

Tennessee's health department states the structural version of the same problem: a state agency's ability to implement facility-level interventions is limited, so its role is confined to feedback and data quality support ("Statewide analysis of NHSN antimicrobial use rate," 2025). Surveillance systems are typically funded to collect and report. The intervention capacity at the receiving end is usually funded separately, or not at all.

Representativeness and denominator bias. The most serious interpretive hazard in multi-hospital AMR data is that resistance percentages depend on who gets cultured. Where blood cultures are taken rarely and only from patients failing empiric therapy, the

resulting isolates are enriched for resistance, and the facility's antibiogram will overstate resistance in the population it serves. Where cultures are taken routinely on admission, the denominator broadens and apparent resistance falls.

This produces a systematic and dangerous artefact: countries with the weakest surveillance and lowest universal health coverage often report the highest apparent resistance levels (Knight, 2025). Some portion of the observed global gradient in resistance is real, and some portion is a gradient in diagnostic access. GLASS 2025 attempts to handle this through Bayesian models that partially capture surveillance-related biases arising from differences in testing practice and coverage (Knight, 2025), which is an improvement on unadjusted comparison but not a substitute for the underlying diagnostic capacity.

The regional picture illustrates the stakes. GLASS 2025 identified large areas of sub-Saharan Africa as contributing little or no data, while the same regions report among the highest apparent resistance (Knight, 2025; WHO, 2025a). A regional median that exceeds the global median only modestly, but which rests on thin and non-representative sampling, should not be over-read in either direction.

Data completeness and infection origin. The 53.8% completeness index described above quantifies the problem at global level (Knight, 2025). Of the specific gaps, the most consequential for stewardship policy is infection origin. Without reliable community-onset versus hospital-onset attribution, it is not possible to distinguish trends driven by hospital transmission, which call for IPC investment, from those driven by community reservoirs and admission of already-colonised patients, which call for very different responses (Knight, 2025). AMASS was designed to stratify by infection origin for exactly this reason ("How to utilize routine antimicrobial resistance surveillance data," 2025; Lim et al., 2020).

Metric limitations and the hazards of mandated reporting. Making reporting mandatory solves participation and creates new problems. Commentators raised substantive concerns before the CMS mandate took effect, arguing that while SAAR has significant promise as a public health and stewardship tool, it was not ready for public reporting or value-based programmes ("The CDC antimicrobial use measure," 2023). The concerns are worth taking seriously on their merits: risk adjustment that is adequate for internal quality improvement may be inadequate when a number carries reputational or financial consequence, and the incentive to manage the metric rather than the underlying practice grows with the stakes.

The R-SAAR work is a direct response to the adjustment critique ("Applying encounter-level risk-adjustment," n.d.), and its finding that more granular adjustment produces extreme values where use is infrequent ("Applying encounter-level risk-adjustment," n.d.) is a caution against assuming that better models resolve the problem for small units and rare drug categories.

A second and less-discussed hazard is that mandatory reporting can crowd out the reporting that is most useful locally. A stewardship programme with limited pharmacist time that must satisfy a federal submission specification may have less capacity remaining for the syndrome-specific analysis that would actually change its guidelines.

Resourcing, quality assurance, and sustainability. The EQA gaps identified in the Eastern Mediterranean Region evaluation ("Implementation of GLASS-AMR," 2025), and evident in sentinel networks elsewhere, are not incidental. A network without EQA cannot distinguish real between-facility variation from methodological variation, which means it cannot support benchmarking, which is the mechanism by which most facility-level policy influence operates. EQA is unglamorous, recurrent-cost infrastructure, and it is chronically under-funded relative to the data systems it validates.

Sustainability is a related concern. Programme funding and custodianship transitions are manageable in well-institutionalised systems such as AURA, where the reporting cycle is established and the participating hospital base is stable (ACSQHC, 2023, 2025a). Where surveillance networks depend on time-limited donor funding, as many LMIC networks do, the risk is that capability built over a funding cycle is not maintained beyond it.

Fragmentation across sectors and settings. Hospital-focused surveillance captures a minority of total antimicrobial consumption in most countries. Integrated systems such as DANMAP and the Australian AURA programme, which incorporates community dispensing data from the Pharmaceutical Benefits Scheme and general practice prescribing from MedicineInsight alongside hospital data (ACSQHC, 2023, 2025a), are better positioned to identify where the largest volumes actually sit. Australia has also documented the limits of even integrated systems: data on the indications for which antimicrobials are prescribed, and on private prescriptions not subsidised through the national scheme, remain a recognised gap (ACSQHC, 2025a).

Supply-side determinants of resistance. Stewardship policy, and the surveillance built to support it, is directed overwhelmingly at prescriber behaviour. A substantial driver of resistance sits upstream of the prescriber and is invisible to every programme in Table 2.

Medicine quality failures, meaning substandard and falsified products, produce sub-therapeutic drug exposure at the point of administration, and the mechanism by which this selects for resistance has been reviewed in detail (Aneke et al., 2022b). A parallel review sets out the case for treating action against falsified medicines in the global pharmaceutical supply chain as an AMR mitigation strategy in its own right (Opara et al., 2025). Neither a SAAR, nor a defined daily dose count, nor a point prevalence

survey distinguishes a correctly prescribed course of a genuine product from a correctly prescribed course of a degraded one. Where medicine quality assurance is weak, a facility can appear to be prescribing appropriately while generating precisely the exposure profile that drives resistance.

The regulatory and supply chain literature identifies the control points. Traceability and chain-of-custody integrity in pharmaceutical distribution is the most load-bearing of these for the argument above: a break anywhere in the chain of custody is precisely the point at which a genuine product can be substituted, diluted, or degraded without detection, which is the mechanism by which sub-therapeutic exposure actually reaches a patient (Aneke & Adesemoye, 2019). Analytical and field-deployable detection methods for substandard and falsified products supply the corresponding countermeasure, allowing a degraded product to be identified before administration rather than inferred afterward from a resistance pattern (Aneke & Adesemoye, 2024). See also risk-based decision-making in good manufacturing practice environments (Aneke & Adesemoye, 2020), risk-based interdiction of illicit medical products at import (Aneke & Adesemoye, 2021), cold chain integrity and good distribution practice for temperature-sensitive products (Aneke & Adesemoye, 2025), and corrective and preventive action effectiveness in quality management systems (Aneke et al., 2022a), which together constitute the remainder of the infrastructure that determines whether the antibiotic administered is the antibiotic recorded. Regulatory harmonisation and convergence frameworks (Aneke et al., 2024), cross-border harmonisation models for African pharmaceutical markets (Eze et al., 2024a), regulatory readiness maturity models (Eze et al., 2022b), and risk-based accelerated approval models (Eze et al., 2024b) describe the governance layer above them.

Access failure is the mirror image and is equally consequential for stewardship policy. The UNGA Access-group target presumes that Access agents are available; where they are not, Watch-group substitution is a supply problem misdiagnosed as a prescribing problem, and stewardship interventions aimed at prescribers will not correct it. Drug shortage early warning and regulatory response models for essential medicines address this directly (Eze et al., 2022a), as does supply chain governance work linking environmental risk management to sustainable access in emerging economies (Eze et al., 2023). At facility and community level, pharmaceutical supply chain inefficiency and its effect on medication affordability (Asiedu & Asiedu, 2023b), last-mile distribution to underserved communities (Asiedu & Asiedu, 2022), equitable access to chronic therapies in hospital pharmacy settings (Asiedu & Asiedu, 2024a), lean process improvement in pharmaceutical inventory and distribution (Asiedu, 2025), manufacturing quality assurance as a determinant of supply reliability (Asiedu & Asiedu, 2024b), and predictive vendor-risk and supply chain resilience models (Tonoyan et al., 2024a) describe the conditions under which an AWARe target is or is not achievable in practice. Where formal supply fails, informal and traditional alternatives fill the gap, and the antimicrobial activity of traditionally used botanical preparations has been characterised in Nigerian settings (Asiedu & Asiedu, 2023a; Gbadamosi & Obogo, 2013). That use is relevant to surveillance chiefly because it falls entirely outside the denominator of every consumption metric discussed in this review.

Comorbidity, polypharmacy, and antimicrobial-only metrics. Surveillance metrics count antimicrobials. They do not count the therapeutic context in which antimicrobials are administered, and that context is changing rapidly in the settings where AMR burden is highest. Work in Nigerian populations links cardiometabolic indices to cardiovascular risk stratification and to renal function in hypertensive adults (Amadi et al., 2025; Okwah, 2022). Renal impairment is directly consequential for antimicrobial dosing, and dose adjustment is one of the specific reasons that days-of-therapy and defined-daily-dose metrics diverge.

The broader chronic disease literature reinforces the point. Guideline-directed management of hypertension and cardiovascular risk is the most direct illustration: antihypertensive and cardioprotective regimens are exactly the concurrent medications most likely to interact with, or share renal clearance pathways with, the antimicrobials under review, which is why the dosing consequence noted above is not a hypothetical one (Abah et al., 2025). The pharmaceutical supply and procurement arrangements that make such long-term therapy available matter for the same reason that supply reliability mattered above: a stock-out of an antihypertensive or other chronic medication changes what a prescriber does with the antimicrobial regimen of a patient already taking it, in ways no antimicrobial-only metric registers (Akin-Oluyomi et al., 2024; Akinleye, 2024). See also dietary and nutritional interventions (David et al., 2025; Ike et al., 2025), which describe the wider lifestyle-management context in which this concurrent burden accumulates; together this literature expands the concurrent medication burden of the average admitted patient. Systematic interaction screening frameworks address the resulting risk at the prescribing interface (Asiedu, 2022), and coordinated multi-site implementation approaches demonstrate how such protocols are standardised across facilities (Omo Enabulele et al., 2025). For stewardship, the practical consequence is that an antimicrobial decision is rarely an isolated one, and a surveillance system that reports antimicrobial exposure without reference to concurrent therapy provides an incomplete basis for the guidance built on it.

4.2. Developments reported through 2025

Genomic integration. WGS has moved from research application toward routine surveillance component. It improves surveillance in ways phenotypic testing cannot: identifying resistance mechanisms rather than only phenotypes, distinguishing clonal expansion from independent acquisition, and detecting transmission missed by conventional methods, with consequent effect on the speed and accuracy of infection control response ("Integrating whole-genome sequencing into antimicrobial resistance surveillance," n.d.; "Genomics for antimicrobial resistance surveillance," 2023). EURGen-Net's 2025 CRE survey operationalises this at continental

scale, with central sequencing support for laboratories lacking capacity (ECDC, 2025b). DANMAP integrated WGS from 2018 (Open University, n.d.), and the Philippine ARSP demonstrated feasibility in an LMIC national programme (Argimon et al., 2020).

The constraints are workflow complexity, bioinformatic capacity, and cost. Quality standards are consolidating: the EU Reference Laboratory for AMR network has published species-specific quality thresholds derived from genomic proficiency testing (Sorensen et al., 2024).

For stewardship policy specifically, the practical value of genomics is currently greater for IPC than for prescribing. Knowing that a carbapenem-resistant *Klebsiella* cluster is clonal changes cohorting and screening decisions immediately; it changes empiric therapy guidance only indirectly.

Automation and near-real-time signal detection. Annual reporting cycles are poorly matched to outbreak response. The integration of SaTScan into WHONET and AMASS provides prospective cluster detection on routine data ("How to utilize routine antimicrobial resistance surveillance data," 2025; "Use of WHONET-SaTScan system," 2017), and the Japanese application across roughly 1,000 hospitals using JANIS data demonstrated automated detection of AMR clusters, many of which were validated against real-time practice ("Enhanced automated detection," 2024). Subsequent work has extended this to rarer species using consistently-tested antimicrobial subsets to construct comparable resistance profiles across facilities ("Enhanced automated detection," 2024).

Machine learning in risk adjustment. The R-SAAR work using gradient-boosted models on encounter-level data from 50 hospitals ("Applying encounter-level risk-adjustment," n.d.) represents the most concrete application of machine learning to network surveillance metrics to date. Its significance is that it widens the range of unit types for which benchmarking is possible while tightening distributions for commonly used agents ("Applying encounter-level risk-adjustment," n.d.).

Diagnostic stewardship as surveillance infrastructure. The recognition that surveillance quality is a function of testing practice has elevated diagnostic stewardship from a clinical concern to a surveillance one. Nigerian national guidance states that facilities participating in AMR surveillance should have robust diagnostic stewardship programmes, and that the quality of routine-data-based AMR surveillance is improved by diagnostic stewardship as an integral part of both patient management and standardised surveillance (NCDC, n.d.). This reframing is correct and under-implemented. Increasing blood culture rates is simultaneously a clinical intervention, a stewardship intervention, and the single most effective way to reduce denominator bias in a facility's surveillance output.

Linking use and resistance analytically. Programmes increasingly collect both AMU and AMR, but few analyse them jointly with adequate method. GLASS reported AMR and antimicrobial consumption data together for the first time in its 2022 report ("Global Antimicrobial Resistance and Use Surveillance System (GLASS 2022)," n.d.). Tennessee's analysis explicitly identified joint analysis with the Antimicrobial Resistance Option as a priority for future work ("Statewide analysis of NHSN antimicrobial use rate," 2025). The Australian NAUSP-NAPS parallel analysis is an early example of what joint analysis makes visible, in that case the combination of high volume and moderate appropriateness ("Antimicrobial consumption and appropriateness," 2025). Ecological association between use and resistance at facility level is methodologically difficult and easily overstated, but the alternative, treating the two datasets as separate reporting streams, forgoes most of the analytic value of collecting both.

One Health interfaces and rapid detection. Hospital surveillance networks observe the terminal point of transmission chains that frequently originate outside the hospital. Integration of artificial intelligence with advanced biosensors for rapid and sensitive detection of antimicrobial-resistant foodborne pathogens represents one route by which the food chain reservoir might be monitored on a timescale compatible with clinical decision-making rather than with annual reporting (Olorunkosebi et al., 2023), and contaminant detection and quantification work in poultry feeds demonstrates the analytic capability already deployed at the agricultural end of the same chain (Tawose et al., 2023). Work on environmental microplastics as vectors for viral transmission within a One Health framing illustrates how environmental compartments carry organisms between reservoirs in ways that neither clinical nor veterinary surveillance observes (Ayinde et al., 2024), and wildlife reservoir studies demonstrate the field methods available at that interface (Ayinde, 2025). Work characterising feed composition and production practice in small ruminant and poultry systems describes the husbandry context in which agricultural antimicrobial exposure occurs, and which hospital surveillance never observes (Oluwadele et al., 2024).

International collaboration is the practical enabler here, as evaluated for parasitic disease control, prevention, and elimination programmes (Nwokedi et al., 2025). The mechanisms described in that work, meaning technology transfer, shared protocols, and joint capacity building, are the same ones that produced the Philippine genomic surveillance programme described earlier (Argimon et al., 2020).

Informatics, dashboards, and anticipatory analytics. The reporting products described earlier are, technically, dashboards, and their design is a well-studied problem outside the AMR field. Frameworks for national real-time disease surveillance dashboards specify the stakeholder-differentiated views, latency requirements, and indicator selection that determine whether such a product is

used or ignored (Oparah et al., 2023), and subsequent work on national-level dashboards for transparent and evidence-based decision-making addresses the governance layer around them (Oparah et al., 2025). Nigeria-specific work on strengthening national health surveillance through data-driven epidemic preparedness describes the same problem in a setting directly comparable to the AMR sentinel networks described earlier (Ogunboye et al., 2023).

Anticipatory analytics is the more speculative frontier. Big data models for anticipating infectious disease outbreaks at population and regional level (Oparah et al., 2022), AI-based risk stratification for large-scale emergency preparedness (Oparah et al., 2021), integration of climate data with health outcomes for mortality risk prediction (Oparah et al., 2024), and quantum-computational approaches to epidemiological modelling (Yusuff et al., 2025) describe an ambition to move surveillance from retrospective description toward forecast. For AMR specifically this remains largely aspirational, because the signal-to-noise ratio in facility-level resistance data is poor and the lag between exposure and resistance emergence is long. The cluster detection work described above is the limited and validated instance of the same principle.

Governance is the constraint on all of it. Comparative analysis of AI-driven healthcare management governance across United States and developing country contexts identifies substantial divergence in executive oversight, regulatory structure, and accountability (Afrihyia et al., 2024), and organisational readiness for generative AI integration differs correspondingly between high-income and low- and middle-income settings (Afrihyia et al., 2025; Ayinde et al., 2025). AI-driven early detection systems for non-communicable disease demonstrate both the capability and the validation burden that accompanies it (Afrihyia et al., 2023). Public health governance models built on process optimisation and performance metrics speak most directly to the surveillance function itself, in that a surveillance network is, administratively, a public health programme whose own throughput and output quality are exactly what such models are designed to track and improve (Anioke & Atima, 2023a). Business intelligence approaches to resource allocation and programme accountability describe the mechanism by which a network's funders decide whether to sustain or expand it, the same resourcing question raised throughout this review in relation to diagnostic and analytic staff (Anioke & Atima, 2023b; Owoade et al., 2022). See also informatics frameworks for protecting vulnerable populations through data-driven policy enforcement (Anioke & Atima, 2023c), equity-oriented service models for underserved populations (Akinse et al., 2023), AI applications in rehabilitation and reintegration services (Yusuff et al., 2025), and operational research on workforce scheduling and its psychosocial effects (Oparah et al., 2024a), which together illustrate the breadth of the informatics and governance apparatus within which a mature surveillance function has to sit.

4.3. Implications for practice and policy

The findings above carry different implications for the several actors involved in a surveillance network, and these are set out here in the order in which they bear on the chain from data capture to clinical action.

For those designing and coordinating networks, the most consequential decision is to specify the feedback product before the data model, defining what a named facility will receive, how often, in what format, and with what interpretive support, and building the collection architecture backward from that specification. Programmes treating feedback as an output of the data system rather than as its purpose under-deliver on policy influence with some consistency. External quality assessment should be funded as a recurrent core cost rather than as a project activity, since benchmarking without it is not defensible and the credibility of the whole network rests on the comparability it establishes. Reporting incidence alongside percentage resistance, and stratifying by infection origin, does more to make surveillance actionable than any expansion in the number of pathogens monitored. Risk adjustment methods and their limitations should be published openly, because acceptance of benchmarking depends on stewardship leads believing that the comparator is fair.

For hospital stewardship programmes, network data is more useful as a prioritisation instrument than as a reporting obligation, and the AU-CAD translation of a benchmark position into a specific number of antimicrobial days is the operational form of that shift (Wolters Kluwer, n.d.). Blood culture utilisation warrants treatment as a stewardship metric in its own right, since it determines the quality of every subsequent surveillance output the facility produces. Volume data should be paired with appropriateness data, because the combination identifies targets that neither identifies alone ("Antimicrobial consumption and appropriateness," 2025).

For national policymakers, the participation lever should be chosen deliberately rather than by default. Payment linkage produces completeness at the cost of gaming pressure, while accreditation linkage preserves the professional framing of surveillance at the cost of some coverage; both are defensible and the choice should be explicit. Surveillance budgets that finance collection and reporting but not facility-level analytic and interventional staff will reproduce the pattern documented in Malawi and comparable settings ("A baseline assessment of antimicrobial stewardship core element implementation," 2025). Periodic inverse auditing, asking what the surveillance system fails to capture rather than only what it reports, is a useful discipline, and the Canadian priority pathogen work of 2025 provides a workable model ("AMR surveillance in Canada," 2025).

For funders and international agencies, diagnostic capacity should take precedence over data systems wherever blood culture rates are low, since sophisticated analytics applied to a sparse and biased isolate stream produce confident wrong answers. Locally-run analytic tools that return output to the facility immediately, following the AMASS model, are the appropriate investment where central analytic capacity rather than data availability is the binding constraint ("How to utilize routine antimicrobial resistance surveillance data," 2025; Lim et al., 2020). Funding should extend beyond the project cycle or be designed for handover from the outset, because capability that lapses at the end of a grant is a poor investment.

For medicines regulators and supply chain actors, medicine quality assurance is properly understood as AMR policy. Post-market surveillance for substandard and falsified antimicrobials belongs alongside consumption surveillance, because the two together describe actual drug exposure while either alone does not (Aneke et al., 2022b; Opara et al., 2025). Shortage early warning should be linked to stewardship guidance, since when an Access-group agent becomes unavailable the substitution pattern is predictable and the stewardship response is better issued before the substitution occurs than measured after it (Eze et al., 2022a). AWaRe performance should be reported alongside availability data, because a 70% Access figure achieved under conditions of Access-agent shortage means something quite different from the same figure achieved under conditions of adequate supply (Eze et al., 2023).

4.4. Limitations of this review

This is a narrative review and is subject to the corresponding limitations. Programme selection was purposive rather than exhaustive, and networks operating in languages other than English, and those in Latin America, the Middle East, and the former Soviet region, are under-represented relative to their epidemiological importance. Much of the evidence on policy influence is observational, self-reported, or drawn from before-and-after designs without concurrent controls, and is vulnerable to secular trend and to publication bias favouring successful programmes. The distinction drawn throughout between surveillance effects and stewardship effects is analytically useful but empirically difficult to maintain, since the two are typically implemented together by the same people. A further limitation concerns the adjacent literature described in the Methods. That material was selected thematically rather than through systematic search of its own fields, it is heterogeneous in study design and in the peer review standards of its publication venues, and a substantial proportion consists of conceptual and framework papers rather than primary empirical studies. It is cited here to characterise the upstream and downstream conditions surrounding surveillance, and claims drawn from it should be read as framing rather than as evidence of effect. Finally, the evidence base is closed at the end of 2025 in a field that moves quickly, and several of the programmes described were mid-cycle at that point, so figures and participation requirements reported here will have moved on.

4.5. Conclusion

Multi-hospital AMR surveillance has changed character over the past decade. It began as an epidemiological description exercise and has become, in the best-developed systems, an active instrument of stewardship policy: setting facility targets, directing audit effort, triggering infection control response, and supplying the numerical basis for national and supranational commitments.

The 2025 evidence supports three conclusions with reasonable confidence. First, the design features that determine policy influence are not primarily epidemiological. They are governance features: the basis of participation, the credibility of risk adjustment, the presence of external quality assurance, and above all the architecture by which comparative data are returned to named facilities. Second, the mechanism by which network surveillance changes prescribing appears to be substantially social, operating through peer comparison and outlier convergence, which means that how a number is presented matters as much as what it measures. Third, the field's central failure is not measurement but reception. Facilities inside functioning surveillance networks routinely lack the staff, mandate, or organisational support to act on what the network tells them, and the adjacent literature on laboratory infrastructure (Aminu-Ibrahim & Ogbete, 2023; Aminu-Ibrahim et al., 2018, 2025b), workforce and service delivery (Fapohunda et al., 2023c; Omaghomi et al., 2022, 2023), medicine quality and access (Aneke et al., 2022b; Eze et al., 2022a; Opara et al., 2025), and health system financing (Akintola et al., 2025; Ilodigwe & Adesemoye, 2019b, 2024b) describes with some consistency why that is so.

The GLASS 2025 finding that one in six bacterial infections globally is now resistant (ICARS, 2025; WHO, 2025a), arriving, as noted above, at the end of the period of most rapid surveillance expansion in the field's history, should be read accordingly. Surveillance has done its job. It has told us, with steadily improving precision, what is happening. Whether the next decade produces different numbers depends far less on further refinement of measurement than on financing the capacity to respond to it, particularly in the settings where apparent resistance is highest and diagnostic access is weakest, and where those two facts are not independent.

Declarations

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References

- A baseline assessment of antimicrobial stewardship core element implementation in selected public hospitals in Malawi: Findings from the 2023 National Program Audit. (2025). <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC12198209/>
- A systematic review of antimicrobial stewardship interventions implemented in intensive care units. (2025). *Journal of Hospital Infection*. [https://www.journalofhospitalinfection.com/article/S0195-6701\(25\)00122-7/abstract](https://www.journalofhospitalinfection.com/article/S0195-6701(25)00122-7/abstract)
- Abah, M. A., Okwah, M. N., Oladosu, M. A., Yohanna, N. R., & Blessing, C. T. (2025). Advances in the management of hypertension: A review of current guidelines, pharmacological therapies, and lifestyle interventions. *Drug and Pharmaceutical Science Archives*, 5(4), 35-41. <https://doi.org/10.47587/DAP.2025.5401>
- Abah, M. A., Okwah, M. N., Oladosu, M. A., Yohanna, N. R., Blessing, C. T., & Vanessa, O. I. (2025). The impact of lifestyle modifications on cardiovascular health: A review of diet, exercise, and stress reduction intervention. *Drug and Pharmaceutical Science Archives*, 5(3), 26-34. <https://doi.org/10.47587/DAP.2025.5301>
- Afrihiya, E., Akinse, S. G., & Ojukwu, P. U. (2023). Development and implementation of an AI-driven early detection system for non-communicable diseases. *International Journal of Advanced Multidisciplinary Research and Studies*, 3(6), 2680-2691.
- Afrihiya, E., Akinse, S. G., & Ojukwu, P. U. (2024). Comparative governance of AI-driven healthcare management: Executive oversight, regulatory structures, and accountability in the United States and developing countries. *International Journal of Advanced Multidisciplinary Research and Studies*, 4(6), 3087-3102. <https://doi.org/10.62225/2583049X.2024.4.6.5920>
- Afrihiya, E., Ojukwu, P. U., & Akinse, S. G. (2024). Privacy-preserving health data governance models: A comparative review of blockchain and cryptographic strategies in U.S. and developing healthcare systems. *International Journal of Advanced Multidisciplinary Research and Studies*, 4(6), 3071-3086. <https://doi.org/10.62225/2583049X.2024.4.6.5919>
- Akin-Oluyomi, O. T., Atima, M. E., & Akinleye, O. K. (2023b). Regulatory compliance and supplier risk assessment frameworks in international pharmaceutical procurement. *International Journal of Advanced Multidisciplinary Research and Studies*, 3(6), 2194-2204.
- Akin-Oluyomi, O. T., Atima, M. E., & Akinleye, O. K. (2024). Cross-border supplier relationship management frameworks for pharmaceutical and global construction sectors. *International Journal of Multidisciplinary Research and Growth Evaluation*, 5(6), 1709-1718.
- Akinleye, O. K. (2024). A sustainable procurement and resilience framework for post-pandemic pharmaceutical operations. *International Journal of Advanced Multidisciplinary Research and Studies*, 4(1), 1602-1621.
- Akinlolu, V. S., Fapohunda, M., Omaghomi, T. T., Atima, M. E., & Igweonu, C. (2023). A proposed care-coordination framework for reducing readmissions among chronic disease patients. *Multidisciplinary Global Environment Journal*, 4(5), 1187-1195.
- Akinlolu, V. S., Omaghomi, T. T., & Fapohunda, M. (2024). A data-driven framework for improving health facility preparedness and disaster risk mitigation in urban hospitals. *International Journal of Advanced Multidisciplinary Research and Studies*, 4.
- Akinlolu, V. S., Omaghomi, T. T., & Fapohunda, M. (2025). A conceptual model for improving orthopedic postoperative outcomes through structured neurovascular monitoring protocols. *International Journal of Advanced Multidisciplinary Research and Studies*, 5.
- Akinlolu, V. S., Omaghomi, T. T., Fapohunda, M., & Atima, M. E. (2022). A systems-level policy framework for integrating mental health screening into primary healthcare in low-resource settings [Unpublished manuscript].
- Akinse, S. G., Ekechi, N. V., & Ohanebo, C. G. (2023). Integrative maternal health model: Addressing socioeconomic inequities in rural populations. *International Journal of Advanced Multidisciplinary Research and Studies*, 3(6), 2832-2838.
- Akinse, S. G., Ohanebo, C. G., & Ekechi, N. V. (2023). A trauma-informed educational framework for adolescents in underserved communities. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, 9(10), 434-443. <https://doi.org/10.32628/CSEIT2361073>
- Akintola, A. S., Fawehinmi, Y. O., Aiyenitaju, O., Chinemerem, B., & Emmanuel, O. (2025). Digital transformation in telehealth: A systematic review of user trust, privacy, and regulatory governance in AI-powered remote monitoring systems. *Journal of Scientific Research and Reports*, 31(11), 163-182. <https://doi.org/10.9734/jsrr/2025/v31i113658>
- Amadi, C. E., Okorafor, U. C., Okorafor, C. I., Okwah, M. N., Akanbi, P. O., Okam, O. V., Udenze, C. I., Mbakwem, A. C., & Ajuluchukwu, J. N. (2025). Association between triglyceride-glucose index and estimated 10-year risk of cardiovascular disease in Nigerian non-diabetic hypertensives: A cross-sectional study. *PLOS Global Public Health*, 5(7), e0004760. <https://doi.org/10.1371/journal.pgph.0004760>
- Aminu-Ibrahim, A. Y., & Ogbete, J. C. (2023). Healthcare infrastructure as a public health intervention using evidence from large laboratory networks. *Shodhshauryam, International Scientific Refereed Research Journal*, 6(1), 256-286. <https://doi.org/10.32628/SHISRRJ23678>
- Aminu-Ibrahim, A. Y., Ogbete, J. C., & Ambali, K. B. (2018). Developing sustainable diagnostic laboratory infrastructure models for emerging and resource constrained health systems. *Iconic Research and Engineering Journals*, 1(8), 118-132. <https://doi.org/10.64388/IREV118-1713586>
- Aminu-Ibrahim, A. Y., Ogbete, J. C., & Ambali, K. B. (2019). Capital project delivery models for high risk healthcare infrastructure in developing national health systems. *Iconic Research and Engineering Journals*, 2(10), 626-649. <https://doi.org/10.64388/IREV2110-1713588>
- Aminu-Ibrahim, A. Y., Ogbete, J. C., & Ambali, K. B. (2020). Infrastructure driven expansion of diagnostic access across underserved and rural healthcare regions. *International Journal of Multidisciplinary Research and Growth Evaluation*, 1(5), 691-706. <https://doi.org/10.54660/IJMRGE.2020.1.5.691-706>
- Aminu-Ibrahim, A. Y., Ogbete, J. C., & Ambali, K. B. (2021). Program management models for coordinated multi-site healthcare infrastructure expansion projects. *International Journal of Multidisciplinary Research and Growth Evaluation*, 2(6), 661-678.
- Aminu-Ibrahim, A. Y., Ogbete, J. C., & Ambali, K. B. (2022). Design and development of high-performance medical laboratories supporting pandemic preparedness and response. *Shodhshauryam, International Scientific Refereed Research Journal*, 5(3), 302-335.

- Aminu-Ibrahim, A. Y., Ogbete, J. C., & Ambali, K. B. (2024). Governance and accountability models for public private partnerships in healthcare infrastructure development. *International Journal of Advanced Multidisciplinary Research and Studies*, 4(6), 2943-2960. <https://doi.org/10.62225/2583049X.2024.4.6.5699>
- Aminu-Ibrahim, A. Y., Ogbete, J. C., & Iwuanyanwu, O. C. (2025a). Cost control and financial accountability frameworks for national healthcare construction programs. *International Journal of Advanced Multidisciplinary Research and Studies*, 5(6), 1970-1990. <https://doi.org/10.62225/2583049X.2025.5.6.5700>
- Aminu-Ibrahim, A. Y., Ogbete, J. C., & Iwuanyanwu, O. C. (2025b). Infrastructure resilience planning for national diagnostic systems under public health stress conditions. *Gyanshauryam, International Scientific Refereed Research Journal*, 8(1), 340-381. <https://doi.org/10.32628/GISRRJ2582311>
- Aminu-Ibrahim, A. Y., Ogbete, J. C., & Iwuanyanwu, O. C. (2025c). Sustainable healthcare infrastructure performance metrics for long-term asset management and value creation. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, 11(4), 566-601. <https://doi.org/10.32628/CSEIT251116277>
- AMR surveillance in Canada: Insights from the 2025 Priority Pathogen List. (2025). <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC12915920/>
- Aneke, O. B., & Adesemoye, A. C. (2019). Toward an integrated conceptual framework for traceability and chain-of-custody integrity in pharmaceutical distribution. *Iconic Research and Engineering Journals*, 3(4), 655-672.
- Aneke, O. B., & Adesemoye, A. C. (2020). A conceptual framework for risk-based decision-making in good manufacturing practice environments. *Iconic Research and Engineering Journals*, 4(6), 325-341.
- Aneke, O. B., & Adesemoye, A. C. (2021). Reframing trade and import compliance: A conceptual model for risk-based interdiction of illicit medical products. *International Journal of Scientific Research in Science and Technology*, 8(6), 1226-1248.
- Aneke, O. B., & Adesemoye, A. C. (2024). Recent advances in analytical and field-deployable methods for detecting substandard and falsified pharmaceuticals. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, 10(5), 1285-1323.
- Aneke, O. B., & Adesemoye, A. C. (2025). Advances in cold chain integrity and good distribution practice for temperature-sensitive pharmaceuticals. *International Journal of Health and Pharmaceutical Research*, 10(3), 99-137.
- Aneke, O. B., Adesemoye, A. C., & Sydney, E. (2022a). Corrective and preventive action effectiveness in pharmaceutical quality management systems: A systematic review of root-cause methodologies. *International Journal of Health and Pharmaceutical Research*, 7(2), 78-111.
- Aneke, O. B., Adesemoye, A. C., & Sydney, E. (2022b). The role of medicine quality failures in the emergence and spread of antimicrobial resistance: A narrative review. *International Journal of Medical Evaluation and Physical Report*, 6(1), 34-62.
- Aneke, O. B., Adesemoye, A. C., & Sydney, E. (2024). Regulatory harmonization and convergence in global medicine quality assurance: A review of frameworks, pathways, and implementation barriers. *International Journal of Medical Evaluation and Physical Report*, 8(6), 213-252.
- Aneke, O. B., Sydney, E., & Adesemoye, A. C. (2023). Data integrity and governance in regulated life sciences operations: A review of failures, controls, and remediation strategies. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, 9(10), 538-568.
- Anioke, S. C., & Atima, M. E. (2023a). Public health governance models using process optimization and performance metrics for regulatory oversight. *International Journal of Advanced Multidisciplinary Research and Studies*, 3(6), 2534-2548. <https://doi.org/10.62225/2583049X.2023.3.6.5491>
- Anioke, S. C., & Atima, M. E. (2023b). Business intelligence applications for mental health resource allocation and public health program accountability. *International Journal of Advanced Multidisciplinary Research and Studies*, 3(6), 2549-2563. <https://doi.org/10.62225/2583049X.2023.3.6.5492>
- Anioke, S. C., & Atima, M. E. (2023c). Public health informatics frameworks for protecting vulnerable populations through data-driven policy enforcement. *International Journal of Advanced Multidisciplinary Research and Studies*, 3(6), 2564-2579.
- Antimicrobial consumption and appropriateness in Australian hospitals: A parallel analysis of 2023 national surveillance data. (2025). <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC12460786/>
- Applying encounter-level risk-adjustment for standardized antimicrobial administration ratios (SAAR): Is it meaningful? (n.d.). *Open Forum Infectious Diseases* (Abstract P-905). <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC12791346/>
- Argimon, S., Masim, M. A. L., Gayeta, J. M., Lagrada, M. L., Macaranas, P. K. V., Cohen, V., Limas, M. T., Espiritu, H. O., Palarca, J. C., Chilam, J., Jamoralin, M. C., Villamin, A. S., Borlasa, J. B., Olorosa, A. M., Hernandez, L. F. T., Boehme, K. D., Jeffrey, B., Abudahab, K., Hufano, C. M., ... Carlos, C. C. (2020). Integrating whole-genome sequencing within the National Antimicrobial Resistance Surveillance Program in the Philippines. *Nature Communications*, 11, 2719. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7264328/>
- Asiedu, C. S. (2022). Drug interaction risk in antenatal care: A conceptual framework for systematic interaction screening. *Shodhsauryam, International Scientific Refereed Research Journal*, 5(3), 465-484.
- Asiedu, C. S. (2023). Diagnostic integration in infectious disease management: A review of microbiology, virology, and serology workflows. *International Journal of Medical Evaluation and Physical Report*, 7(4), 173-195. <https://doi.org/10.56201/ijmepr.v7.no4.2023.pg173.195>
- Asiedu, C. S. (2024). Droplet digital PCR for HIV viral reservoir quantification: A review of diagnostic accuracy and clinical utility. *International Journal of Medical Evaluation and Physical Report*, 8(6), 253-273. <https://doi.org/10.56201/ijmepr.v8.no6.2024.pg253.273>
- Asiedu, C. S. (2025). A lean process-improvement framework for pharmaceutical inventory and distribution management. *International Journal of Health and Pharmaceutical Research*, 10(12), 225-252. <https://doi.org/10.56201/ijhpr.vol.10.no12.2025.pg225.252>
- Asiedu, C. S., & Asiedu, A. A. (2022). Last-mile drug distribution to underserved communities: A review of barriers and intervention models. *Gyanshauryam, International Scientific Refereed Research Journal*, 5(6), 439-466.
- Asiedu, C. S., & Asiedu, A. A. (2023a). Comparative bioavailability of fresh versus dried botanical compounds: A review and cost-effectiveness modelling framework. *Research Journal of Pure Science and Technology*, 6(3), 226-244. <https://doi.org/10.56201/rjpst.v6.no3.2023.pg226.244>
- Asiedu, C. S., & Asiedu, A. A. (2023b). Pharmaceutical supply chain inefficiencies and medication affordability in resource-constrained health systems: A narrative review. *International Journal of Health and Pharmaceutical Research*, 8(4), 192-222. <https://doi.org/10.56201/ijhpr.v8.no4.2023.pg192.222>
- Asiedu, C. S., & Asiedu, A. A. (2024a). Equitable access to chronic therapies in hospital pharmacy settings: A conceptual framework for continuity of care. *International Journal of Medical Evaluation and Physical Report*, 8(6), 274-298. <https://doi.org/10.56201/ijmepr.v8.no6.2024.pg274.298>
- Asiedu, C. S., & Asiedu, A. A. (2024b). Reconceptualizing quality assurance in pharmaceutical manufacturing as a determinant of supply reliability. *International Journal of Health and Pharmaceutical Research*, 9(5), 148-173. <https://doi.org/10.56201/ijhpr.v9.no5.2024.pg148.173>
- Australian Commission on Safety and Quality in Health Care. (2023). Fifth Australian report on antimicrobial use and resistance in human health (AURA 2023). <https://www.safetyandquality.gov.au/publications-and-resources/resource-library/aura-2023-fifth-australian-report-antimicrobial-use-and-resistance-human-health>
- Australian Commission on Safety and Quality in Health Care. (2025a). Antimicrobial Use and Resistance in Australia (AURA). <https://www.safetyandquality.gov.au/clinical-topics/antimicrobial-use-and-resistance-australia-aura>
- Australian Commission on Safety and Quality in Health Care. (2025b). Hospital and aged care antimicrobial use. <https://www.safetyandquality.gov.au/our-work/antimicrobial-resistance/antimicrobial-use-and-resistance-australia-aura/hospital-and-aged-care-antimicrobial-use>
- Australian Commission on Safety and Quality in Health Care. (n.d.). Australia's hospitals helping the fight against antibiotic resistance [Media release]. <https://www.safetyandquality.gov.au/about-us/latest-news/media-releases/australias-hospitals-helping-fight-against-antibiotic-resistance>
- Ayinde, M. K. (2025). West Nile virus dynamics in American robins (*Turdus migratorius*; AMRO) of Illinois [Unpublished thesis]. Western Illinois University.

- Ayinde, M. K., Penddahi, A. L., Mensah, G. K., & Olorunkosebi, M. T. (2024). Environmental microplastics as vectors for avian virus transmission and their implications for food safety within a one health framework. *Journal of Current Research in Food Science*, 5(2), 210-219. <https://doi.org/10.22271/foodsci.2024.v5.i2c.288>
- Ayinde, M., Ojukwu, P. U., & Ohunyon, G. (2025). Organizational readiness for generative AI integration in healthcare operations: Comparative management capabilities between the U.S. and low- and middle-income countries. *International Journal of Advanced Multidisciplinary Research and Studies*, 5(6), 2207-2222. <https://doi.org/10.62225/2583049X.2025.5.6.6007>
- Centers for Disease Control and Prevention. (2025a). Using NHSN AUR Module for the Medicare Promoting Interoperability Program: Facility guidance. <https://www.cdc.gov/nhsn/pdfs/cda/phdi-facility-guidance-508.pdf>
- Centers for Disease Control and Prevention. (2025b). FAQs: Antimicrobial Resistance (AR) Option, National Healthcare Safety Network. <https://www.cdc.gov/nhsn/faqs/faq-ar.html>
- Council of the European Union. (2023). Council Recommendation on stepping up EU actions to combat antimicrobial resistance in a One Health approach (2023/C 220/01). Official Journal of the European Union.
- David, F. T., Abah, M. A., Oladosu, M. A., Agida, O. D., Clive, N. O., Adebukola, A. M., Nnabuko, O. M., & Maryanne, O. U. (2025). The impact of plant-based diets on cardiovascular health: A comprehensive review. *Plant Science Archives*, 10(4), 51-59. <https://doi.org/10.51470/PSA.2025.10.4.51>
- Ejofodomi, O. A., Gideon, E. N., Oladipo, G. O., & Oshomah, E. R. (2014). Automated detection of architectural detection in mammograms using template matching. *International Journal of Biomedical Science and Engineering*, 2(1), 1-6. <https://doi.org/10.11648/j.ijbse.20140201.11>
- Enhanced automated detection of outbreaks of a rare antimicrobial-resistant bacterial species. (2024). <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC11500894/>
- European Centre for Disease Prevention and Control. (2022). External quality assessment of the performance of laboratories participating in EARS-Net, 2022. <https://www.ecdc.europa.eu/en/node/37372>
- European Centre for Disease Prevention and Control. (2025a). Antimicrobial resistance in the EU/EEA (EARS-Net): Annual epidemiological report for 2024. <https://www.ecdc.europa.eu/en/publications-data/antimicrobial-resistance-eueea-ears-net-annual-epidemiological-report-2024>
- European Centre for Disease Prevention and Control. (2025b). European Antimicrobial Resistance Genes Surveillance Network (EURGen-Net). <https://www.ecdc.europa.eu/en/about-us/who-we-work/disease-and-laboratory-networks/EURGen-net>
- Eze, F. I., Akinleye, O. K., & Anene, U. N. (2024a). Development of a cross-border regulatory harmonization model for African pharmaceutical markets: The ARCH-Model framework. *International Journal of Health and Pharmaceutical Research*, 9(5), 148-186. <https://doi.org/10.56201/ijhpr.v9.no5.2024.pg148.186>
- Eze, F. I., Akinleye, O. K., & Anene, U. N. (2024b). Development of a risk-based accelerated approval decision model balancing speed, safety, and evidence quality in pharmaceutical regulatory science. *Research Journal of Pure Science and Technology*, 7(6), 120-161. <https://doi.org/10.56201/rjps.v7.no6.2024.pg120.161>
- Eze, F. I., Anene, U. N., & Akinleye, O. K. (2022a). Creation of a drug shortage early warning and regulatory response model for essential medicines in global health systems. *Research Journal of Pure Science and Technology*, 5(1), 57-95. <https://doi.org/10.56201/rjps.v5.no1.2022.pg57.95>
- Eze, F. I., Anene, U. N., & Akinleye, O. K. (2022b). Design of an integrated regulatory readiness maturity model for pharmaceutical companies seeking global market entry. *International Journal of Health and Pharmaceutical Research*, 7(1), 77-112. <https://doi.org/10.56201/ijhpr.v7.no1.2022.pg77.112>
- Eze, F. I., Anene, U. N., & Akinleye, O. K. (2023). Pharmaceutical supply chain governance, environmental risk management, and sustainable access to essential medicines in emerging economies: The PSCG-ERM framework. *International Journal of Health and Pharmaceutical Research*, 8(4), 192-241. <https://doi.org/10.56201/ijhpr.v8.no4.2023.pg192.241>
- Fapohunda, M., Akinlolu, V. S., & Omaghomi, T. T. (2023a). A conceptual framework for enhancing telehealth adoption among rural and underserved populations in Nigeria and the United States [Unpublished manuscript].
- Fapohunda, M., Akinlolu, V. S., Omaghomi, T. T., & Atima, M. E. (2023b). A proposed framework for strengthening patient safety in high-acuity nursing units through integrated clinical policies [Unpublished manuscript].
- Fapohunda, M., Akinlolu, V. S., Omaghomi, T. T., & Efetobore, M. (2025a). A policy and research framework for strengthening emergency response coordination across hospital units. *International Journal of Health and Pharmaceutical Research*, 10(12), 34-51.
- Fapohunda, M., Omaghomi, T. T., & Akinlolu, V. S. (2024). A proposed framework for improving postoperative pain management through integrated nursing communication pathways. *International Journal of Advanced Multidisciplinary Research and Studies*, 4.
- Fapohunda, M., Omaghomi, T. T., & Akinlolu, V. S. (2025b). A proposed model for improving patient flow efficiency through interdepartmental coordination and digital tracking systems. *World Journal of Innovation and Modern Technology*, 9(12), 129-149.
- Fapohunda, M., Omaghomi, T. T., Akinlolu, V. S., & Atima, M. E. (2025c). A policy-oriented framework for strengthening behavioral health crisis response systems in multi-hospital networks. *International Journal of Health and Pharmaceutical Research*, 10(12), 34-51.
- Fapohunda, M., Omaghomi, T. T., Akinlolu, V. S., Igweonu, C., & Atima, M. E. (2023). A policy-based model for strengthening antimicrobial stewardship programs in emerging economies [Unpublished manuscript / preprint].
- Gbadamosi, I. T., & Obogo, S. F. (2013). Chemical constituents and in vitro antimicrobial activities of five botanicals used traditionally for the treatment of neonatal jaundice in Ibadan, Nigeria. *Nature and Science*, 11(10), 130-135.
- Genomics for antimicrobial resistance surveillance to support infection prevention and control in health-care facilities. (2023). *The Lancet Microbe*.
- Global Antimicrobial Resistance and Use Surveillance System (GLASS 2022): Investigating the relationship between antimicrobial resistance and antimicrobial consumption data across the participating countries. (n.d.). <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10843100/>
- GlobalAMR. (2025). GLASS-2025: Code repository for the Global Antimicrobial Resistance and Use Surveillance System 2025 report. GitHub. <https://github.com/GlobalAMR/GLASS-2025>
- Hillock, N., Connor, E., Wilson, C., & Kennedy, B. (2021). Comparative analysis of Australian hospital antimicrobial utilization, using the WHO AWaRe classification system and the adapted Australian Priority Antimicrobial List. *JAC-Antimicrobial Resistance*, 3(1).
- How to utilize routine antimicrobial resistance surveillance data for local and national actions in an LMIC. (2025). *JAC-Antimicrobial Resistance*, 7(6), dlaf225. <https://academic.oup.com/jacamr/article/7/6/dlaf225/8362517>
- Igweonu, C., Omaghomi, T. T., Fapohunda, M., Akinlolu, V. S., & Atima, M. E. (2024). A strategic policy framework for enhancing continuity of care in patients with cardiometabolic conditions [Manuscript; publication venue to be verified].
- Ike, P. C., Enyinnaya, A. C., Ujam, C. G., Ayinde, M. K., Golden, F. I., Olatokun, T. P., & Nasir, K. (2025). Investigating the relationship between nutrition and DNA markers associated with heart health in middle-aged adults with type 2 diabetes. *International Journal of Convergent and Informatics Science Research*, 8(9). <https://doi.org/10.70382/hijcirs.v08i9.035>
- Ilodigwe, L., & Adesemoye, A. C. (2019a). A critical review of health insurance financing mechanisms and provider payment reform strategies for balancing coverage expansion and financial protection in emerging markets. *International Journal of Health and Pharmaceutical Research*, 5(2), 31-55. <https://doi.org/10.56201/ijhpr.vol.5.no2.2019.pg31.55>
- Ilodigwe, L., & Adesemoye, A. C. (2019b). From molecules to health systems: A conceptual model explaining why scientific innovation fails to improve patient outcomes without effective healthcare delivery infrastructure. *International Journal of Health and Pharmaceutical Research*, 5(2), 56-79. <https://doi.org/10.56201/ijhpr.vol.5.no2.2019.pg56.79>

- Ilodigwe, L., & Adesemoye, A. C. (2020). Advances in pharmacy-led delivery and access models for strengthening primary healthcare systems and expanding medicine availability in emerging markets. *International Journal of Health and Pharmaceutical Research*, 5(3), 78-96. <https://doi.org/10.56201/ijhpr.vol.5.no3.2020.pg78.96>
- Ilodigwe, L., & Adesemoye, A. C. (2021). The data backbone of health system transformation: A governance and architecture framework for interoperability, data quality, and advanced analytics at national scale. *International Journal of Health and Pharmaceutical Research*, 6(2), 52-76. <https://doi.org/10.56201/ijhpr.vol.6.no2.2021.pg52.76>
- Ilodigwe, L., & Adesemoye, A. C. (2024a). Advances in real-world evidence, predictive analytics, and data-driven decision making for improving health system performance and patient outcomes. *International Journal of Health and Pharmaceutical Research*, 9(5), 174-197. <https://doi.org/10.56201/ijhpr.v9.no5.2024.pg174.197>
- Ilodigwe, L., & Adesemoye, A. C. (2024b). Beyond technology: A strategic framework for building sustainable and resilient health systems through organizational strategy, operational excellence, and workforce capability. *International Journal of Medical Evaluation and Physical Report*, 8(6), 299-319. <https://doi.org/10.56201/ijmepr.v8.no6.2024.pg299.319>
- Ilodigwe, L., & Adesemoye, A. C. (2025a). Advances, risks, and implementation challenges of artificial intelligence as a force multiplier for clinical decision making and health system efficiency. *International Journal of Medical Evaluation and Physical Report*, 9(7), 165-185. <https://doi.org/10.56201/ijmepr.v9.no7.2025.pg165.185>
- Ilodigwe, L., & Adesemoye, A. C. (2025b). Executing healthcare transformation at scale: A strategic change model derived from large programs across payers, providers, and integrated health systems. *International Journal of Health and Pharmaceutical Research*, 10(12), 253-272. <https://doi.org/10.56201/ijhpr.vol.10.no12.2025.pg253.272>
- Implementation of GLASS-AMR: An assessment in WHO's Eastern Mediterranean Region. (2025). <https://www.sciencedirect.com/science/article/pii/S3050456225000355>
- Increasing the use of the WHO AWaRe system in antibiotic surveillance and stewardship programmes in low- and middle-income countries. (2025). <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC11919820/>
- Integrating whole-genome sequencing into antimicrobial resistance surveillance: Methodologies, challenges, and perspectives. (n.d.). *Clinical Microbiology Reviews*. International Centre for Antimicrobial Resistance Solutions. (2025, October 20). ICARS welcomes the new WHO GLASS report on global AMR trends. <https://icars-global.org/glass-report-2025/>
- International Institute for Sustainable Development. (2024, October). Countries commit to increased action on antimicrobial resistance. *SDG Knowledge Hub*. <https://sdg.iisd.org/news/countries-commit-to-increased-action-on-antimicrobial-resistance/>
- Knight, G. M. (2025, November). WHO's 2025 GLASS report: Progress, patterns and persistent gaps. *London School of Hygiene and Tropical Medicine*. <https://www.lshrm.ac.uk/research/amr/news/473666/whos-2025-glass-report-progress-patterns-and-persistent-gaps>
- Lim, C., Hantrakun, V., Klaytong, P., Rangsiwutisak, C., Tangwangvivat, R., Phetrak, A., Dunachie, S. J., Hinjoy, S., Iamsirithaworn, S., Day, N. P. J., Peacock, S. J., & Limmathurotsakul, D. (2020). Automating the generation of antimicrobial resistance surveillance reports: Proof-of-concept study involving seven hospitals in seven countries. *Journal of Medical Internet Research*, 22(10), e19762. <https://www.jmir.org/2020/10/e19762>
- Nigeria Centre for Disease Control and Prevention. (n.d.). Guideline for antimicrobial resistance surveillance. NCDC. https://ncdc.gov.ng/themes/common/docs/protocols/368_1751958974.pdf
- Nnaji, N., & Akinlolu, V. S. (2022). Reducing decision delays through real-time health informatics and performance analytics. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*.
- Nnaji, N., & Akinlolu, V. S. (2023). Addressing productivity and workflow inefficiencies using analytics-driven performance models in healthcare operations. *Shodhshauryam, International Scientific Refereed Research Journal*.
- Nnaji, N., & Akinlolu, V. S. (2024a). Enhancing clinical record protection through structured health data security frameworks in regulated healthcare environments. *International Journal of Scientific Research in Humanities and Social Sciences*.
- Nnaji, N., & Akinlolu, V. S. (2024b). Strengthening medical information flow through digital operations models for modern mental health care. *Gyanshauryam, International Scientific Refereed Research Journal*, 7.
- Nwokedi, V. U., Akanbi, O. O., Ayo-ige, B. A., Aderounmu, R. A., Kassim, N. O., Aneke, O. B., Inumimo, O., Ilesanmi, O. J., Luper, T., & Farinde, T. D. (2025). Evaluating the role and impact of international collaboration and partnerships on the control, prevention, and elimination of parasitic diseases: A global health perspective. *Australian Journal of Biomedical Research*, 1(2), Article aubm009.
- Obi, L. I., Dogbanya, G., Awah, L. C., Tawose, O. M., Ubani, C., Ayo-ige, A. B., Odelede, M., & Edafeadhe, O. (2025). A systematic analysis of effectiveness of nurse-led dementia care interventions on health outcomes among community-dwelling older adults. *Journal of Pharma Insights and Research*, 3(5), 24-33. <https://doi.org/10.69613/3f5cq717>
- Ogbete, J. C., & Aminu-Ibrahim, A. Y. (2024). Translating healthcare infrastructure investment into measurable population health and diagnostic outcomes. *International Journal of Scientific Research in Humanities and Social Sciences*, 1(2), 955-985. <https://doi.org/10.32628/IJRSSH242775>
- Ogbete, J. C., Aminu-Ibrahim, A. Y., & Ambali, K. B. (2018). Optimizing laboratory spatial planning strategies to improve diagnostic accuracy, safety, and clinical throughput. *Iconic Research and Engineering Journals*, 2(1), 87-113. <https://doi.org/10.64388/IREV117-1713587>
- Ogbete, J. C., Aminu-Ibrahim, A. Y., & Ambali, K. B. (2019). Regulatory compliant design systems for molecular and pathology laboratories in highly controlled environments. *Iconic Research and Engineering Journals*, 3(4), 607-631. <https://doi.org/10.64388/IREV314-1713589>
- Ogbete, J. C., Aminu-Ibrahim, A. Y., & Ambali, K. B. (2020). Sustainable materials selection and energy efficiency strategies for modern medical laboratory facilities. *International Journal of Multidisciplinary Research and Growth Evaluation*, 1(5), 674-690. <https://doi.org/10.54660/IJMRGE.2020.1.5.674-690>
- Ogbete, J. C., Aminu-Ibrahim, A. Y., & Ambali, K. B. (2021). Risk managed construction strategies for complex and highly regulated healthcare facility developments. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, 7(5), 362-392. <https://doi.org/10.32628/CSEIT217561>
- Ogbete, J. C., Aminu-Ibrahim, A. Y., & Ambali, K. B. (2022). Design standards and operational planning frameworks for scalable blood collection networks. *Gyanshauryam, International Scientific Refereed Research Journal*, 5(6), 267-300. <https://doi.org/10.32628/GISRRJ225635>
- Ogbete, J. C., Aminu-Ibrahim, A. Y., & Ambali, K. B. (2023). Lifecycle performance evaluation of purpose built diagnostic laboratories supporting long term healthcare delivery. *International Journal of Advanced Multidisciplinary Research and Studies*, 3(6), 2605-2621. <https://doi.org/10.62225/2583049X.2023.3.6.5698>
- Ogbete, J. C., Aminu-Ibrahim, A. Y., & Iwuanyanwu, O. C. (2025a). Digital and BIM enabled coordination methods for delivering complex medical facility projects. *International Journal of Advanced Multidisciplinary Research and Studies*, 5(6), 1991-2010. <https://doi.org/10.62225/2583049X.2025.5.6.5701>
- Ogbete, J. C., Aminu-Ibrahim, A. Y., & Iwuanyanwu, O. C. (2025b). Integrating healing-centered design principles into diagnostic and laboratory facility planning. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, 11(6), 516-553. <https://doi.org/10.32628/CSEIT251117149>
- Ogunboye, I., Adebayo, I. P. S., Anioke, S. C., Egwuatu, E. C., Ajala, C. F., & Awuah, S. B. (2023). Enhancing Nigeria's health surveillance system: A data-driven approach to epidemic preparedness and response. *World Journal of Advanced Research and Reviews*.

- Ohunyon, G., Ayinde, M., & Ojukwu, P. U. (2023). The impact of multidisciplinary collaboration on patient outcomes in emergency departments. *International Journal of Advanced Multidisciplinary Research and Studies*, 3(6), 2727-2741. <https://doi.org/10.62225/2583049X.2023.3.6.6029>
- Ohunyon, G., Ayinde, M., & Ojukwu, P. U. (2024). Evidence-based wound care management in acute hospital settings. *International Journal of Advanced Multidisciplinary Research and Studies*, 4(6), 3186-3199. <https://doi.org/10.62225/2583049X.2024.4.6.6066>
- Ohunyon, G., Ojukwu, P. U., & Ayinde, M. (2025). Developing nurse leadership capacity in residential care facilities. *International Journal of Advanced Multidisciplinary Research and Studies*, 5(6), 2299-2312. <https://doi.org/10.62225/2583049X.2025.5.6.6065>
- Okwah, M. N. (2022). Integrating triglyceride-glucose index and echocardiographic parameters for improved cardiovascular risk stratification in Sub-Saharan Africa. *International Journal of Cardiology*, 1(2), 1-16. https://doi.org/10.34218/IJC_01_02_001
- Olorunkosebi, M. T., Ayinde, M. K., & Mensah, G. K. (2023). Integrating artificial intelligence and advanced biosensors for rapid and sensitive detection of antimicrobial resistant foodborne pathogens. *Journal of Advances in Microbiology Research*, 4(2), 175-182. <https://doi.org/10.22271/micro.2023.v4.i2b.293>
- Oluwadele, J. F., Ekeocha, A. H., Aganga, A. A., Tawose, O. M., Odumboni, A., Oforome, C. I., & Akinlabi, E. Y. (2024). Effects of feeding *Pennisetum purpureum* silage supplemented with selected farm residues on growth performance and meat quality of West African dwarf rams. *SVU-International Journal of Agricultural Sciences*, 6(3), 190-196. https://svuijas.journals.ekb.eg/article_384457.html
- Omaghomi, T. T., Akinlolu, V. S., & Fapohunda, M. (2023). A governance-driven framework for improving workforce planning and nurse-patient ratio optimization in public hospitals. *Multidisciplinary Journal of Educational Research*, 4(6), 1357-1368.
- Omaghomi, T. T., Akinlolu, V. S., & Fapohunda, M. (2025). A conceptual model for integrating community health workers into national immunization programs to boost vaccine uptake. *International Journal of Advanced Multidisciplinary Research and Studies*, 5.
- Omaghomi, T. T., Fapohunda, M., & Akinlolu, V. S. (2022). Multidimensional framework for strengthening infection prevention and control (IPC) compliance in tertiary hospitals. *Multidisciplinary Global Environment Journal*, 3(6), 888-896.
- Omaghomi, T. T., Fapohunda, M., Akinlolu, V. S., & Efetobore, M. (2024). A conceptual framework for improving fall prevention outcomes through policy-integrated nursing workflows. *International Journal of Advanced Multidisciplinary Research and Studies*, 4.
- Omaghomi, T. T., Igweonu, C., Fapohunda, M., Akinlolu, V. S., & Atima, M. E. (2025). A policy-driven framework for enhancing chronic disease management in underserved US communities. *International Journal of Advanced Multidisciplinary Research and Studies*, 5.
- Omo Enabulele, A. B., Oyebamiji, I., Ikubanni, O., Okwah, M. N., Babalola, W. S., Azeez, O. M., & Olaniyi, A. O. (2025). A coordinated project-management approach to multisite implementation of motor-rehabilitation programs for children with autism spectrum disorder in United States healthcare systems: A narrative review. *Cureus*, 17(12), e100513. <https://doi.org/10.7759/cureus.100513>
- Opara, I. J., Olatunbosun, A., Adeola, O. D., Aneke, O. B., Somuah, M. A., & Olorunkosebi, M. T. (2025). A review on mitigating antimicrobial resistance by combating falsified medicines in the global pharmaceutical supply chain. *Journal of Pharma Insights and Research*, 3(5), 206-214.
- Oparah, O. S., Ezech, F. E., Olatunji, G. I., & Ajayi, O. O. (2021). AI-based risk stratification framework for large-scale public health emergency preparedness and response planning. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, 7(1), 332-366.
- Oparah, O. S., Ezech, F. E., Olatunji, G. I., & Ajayi, O. O. (2022). Big data-enabled predictive models for anticipating infectious disease outbreaks at population and regional levels. *International Journal of Advanced Multidisciplinary Research and Studies*.
- Oparah, O. S., Ezech, F. E., Olatunji, G. I., & Ajayi, O. O. (2023). Framework for designing national real-time disease surveillance dashboards for public health stakeholders. *Shodhshauryam, International Scientific Refereed Research Journal*, 6(1), 208-227.
- Oparah, O. S., Ezech, F. E., Olatunji, G. I., & Ajayi, O. O. (2024). Framework for integrating climate data and health outcomes to improve mortality risk prediction systems. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, 10(2), 1128-1150.
- Oparah, O. S., Ezech, F. E., Olatunji, G. I., & Ajayi, O. O. (2025). Conceptual design of national-level public health dashboards for transparent and evidence-based decision-making. *International Journal of Applied Research in Social Sciences*, 7(10), 805-826.
- Oparah, O. S., Gado, P., Ezech, F. E., Gbaraba, S. V., Omotayo, O., & Adeleke, A. S. (2021). Framework for scaling mobile health solutions for chronic disease monitoring and treatment adherence improvement. *International Journal of Advanced Multidisciplinary Research and Studies*, 2(4).
- Oparah, S. O., Gado, P., Ezech, F. E., Gbaraba, S. V., & Adeleke, A. S. (2024a). Assessing the operational and psychosocial impact of the compressed workweek: A meta-analytic review of four-day work week trials across industries. *International Journal of Advanced Multidisciplinary Research and Studies*.
- Oparah, S. O., Gado, P., Ezech, F. E., Gbaraba, S. V., & Suliat, A. (2024b). Comprehensive review of telehealth effectiveness in bridging rural-urban disparities in healthcare access. *International Journal of Advanced Multidisciplinary Research and Studies*.
- Open University. (n.d.). Whole genome sequencing in AMR surveillance. OpenLearn Create. <https://www.open.edu/openlearncreate/mod/oucontent/view.php?id=236281>
- Orise, C., & Niniola, S. (2022). Real-time analytics for educational excellence: A conceptual framework for performance dashboards in health professional training. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, 8(2), 802-815.
- Orise, C., & Niniola, S. (2023). Privacy, safeguarding, and ethical data practices in healthcare EdTech: A conceptual model for compliance and trust. *Shodhshauryam, International Scientific Refereed Research Journal*, 6(1), 507-529.
- Orise, C., & Niniola, S. (2024). Digital equity in healthcare education: A systematic review of access frameworks and interventions for underrepresented learners in clinical training. *International Journal of Scientific Research in Humanities and Social Sciences*, 1(2), 1233-1246.
- Orise, C., & Niniola, S. (2025). Data governance in digital health learning systems: A systematic review of implementation frameworks and best practices. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, 11(5), 520-538.
- Owoade, O. A., Moneke, K. C., & Anioke, S. C. (2022). Leveraging business intelligence to optimize resource allocation in mental health and substance abuse centers. *Journal of Scientific and Engineering Research*, 9(12), 210-235.
- Park, D. E., Roberts, A. L. S., Hamdy, R. F., Balthrop, S., Dolan, P., & Liu, C. M. (2025). Evaluating an urgent care antibiotic stewardship intervention: A multi-network collaborative effort. *Infection Control & Hospital Epidemiology*.
- Pauwels, I., Versporten, A., Vermeulen, H., Vlieghe, E., & Goossens, H. (2021). Assessing the impact of the Global Point Prevalence Survey of Antimicrobial Consumption and Resistance (Global-PPS) on hospital antimicrobial stewardship programmes: Results of a worldwide survey. *Antimicrobial Resistance and Infection Control*, 10, 138.
- Prime Progress NG. (2025, November). Nigeria's expanding network of solutions for antimicrobial resistance. <https://primeprogressng.com/prime-health/nigerias-expanding-network-of-solutions-for-antimicrobial-resistance/>
- Qualitative evaluation of a statewide antibiotic stewardship quality improvement sepsis intervention. (n.d.). <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC12912922/>
- SA Health. (n.d.). About the National Antimicrobial Utilisation Surveillance Program (NAUSP). Government of South Australia. <https://www.sahealth.sa.gov.au/>
- Shealy, S., Kohn, J., Yongue, E., Troficanto, C., Bookstaver, P. B., Justo, J. A., Winders, H. R., Dash, S., & Al-Hasan, M. N. (2021). Application of standardized antimicrobial administration ratio as a motivational tool within a multi-hospital healthcare system. *Pharmacy*, 9(1), 32.
- Sorensen, L. H., Karlsmose Pedersen, S., Jensen, J. D., Hendriksen, R. S., Aarestrup, F. M., & Hasman, H. (2024). Whole-genome sequencing for antimicrobial surveillance: Species-specific quality thresholds and data evaluation from the network of the European Union Reference Laboratory for Antimicrobial Resistance genomic proficiency tests of 2021 and 2022. *mSystems*.

- Statewide analysis of NHSN antimicrobial use rate and standardized antimicrobial administration ratio (SAAR) 2017-2023, Tennessee. (2025). <https://pmc.ncbi.nlm.nih.gov/articles/PMC12345046/>
- Strengthening antimicrobial stewardship in Nigeria: Qualitative and quantitative insights into barriers, enablers, and implementation strategies (2015-2025). (2025). medRxiv. <https://www.medrxiv.org/content/10.1101/2025.11.04.25339461>
- Tawose, O. M., Oluwadele, J. F., Ekeocha, A. H., Odumboni, A. A., & Egbeyemi, O. S. (2023). Aflatoxin detection and quantification in poultry feeds available in selected areas in Ekiti State. *FUOYE Journal of Agriculture and Human Ecology*, 7(2). <https://doi.org/10.62923/fuojahe.v7i2.302>
- The CDC antimicrobial use measure is not ready for public reporting or value-based programs. (2023). *Antimicrobial Stewardship & Healthcare Epidemiology*. <https://www.cambridge.org/core/journals/antimicrobial-stewardship-and-healthcare-epidemiology/article/852C97BC1EC31C40A7B418A60882EF97>
- Tonoyan, A., Dada, O., & Ayivi-Donkor, S. S. (2024a). Advances in supply chain resilience: Predictive models for vendor risk assessment and procurement cost optimization. *International Journal of Social Sciences and Management Research*, 10(11), 525-551. <https://doi.org/10.56201/ijssmr.v10.no11.2024.pg.525.551>
- Uduokhai, D. O., Nwafor, M. I., Sanusi, A. N., & Garba, B. M. P. (2025b). Predictive framework for optimizing maintenance schedules in aging public infrastructure systems. *Global Journal of Engineering and Technology Review*, 1(3), 142-152.
- United Nations Environment Programme. (2024, September 26). World leaders commit to decisive action on antimicrobial resistance [Press release]. <https://www.unep.org/news-and-stories/press-release/world-leaders-commit-decisive-action-antimicrobial-resistance>
- United Nations General Assembly. (2024). Political declaration of the high-level meeting on antimicrobial resistance. United Nations. <https://www.un.org/pga/wp-content/uploads/sites/108/2024/09/FINAL-Text-AMR-to-PGA.pdf>
- Use of WHONET-SaTScan system for simulated real-time detection of antimicrobial resistance clusters in a hospital in Italy, 2012 to 2014. (2017). *Eurosurveillance*. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5356424/>
- Versporten, A., Zarb, P., Caniaux, I., Gros, M.-F., Drapier, N., Miller, M., Jarlier, V., Nathwani, D., & Goossens, H. (2015). Global Point Prevalence Survey of Antimicrobial Consumption and Resistance (Global-PPS): A worldwide antimicrobial web-based point prevalence survey. *Open Forum Infectious Diseases*, 2(Suppl. 1). https://academic.oup.com/ofid/article/2/suppl_1/147/2634706
- WHONET. (n.d.). Microbiology laboratory database software. WHO Collaborating Centre for Surveillance of Antimicrobial Resistance. <https://whonet.org/>
- Wolters Kluwer. (2025, May). Antimicrobial use and resistance: Updates to NHSN and CMS reporting. <https://www.wolterskluwer.com/en/expert-insights/antimicrobial-use-and-resistance-updates-to-nhsn-and-cms-reporting>
- Wolters Kluwer. (n.d.). SAAR can lift antimicrobial stewardship to new heights. <https://www.wolterskluwer.com/en/expert-insights/saar-can-lift-antimicrobial-stewardship-to-new-heights>
- World Health Organization. (2025a). Global antibiotic resistance surveillance report 2025: WHO Global Antimicrobial Resistance and Use Surveillance System (GLASS). <https://www.who.int/publications/i/item/9789240116337>
- World Health Organization Regional Office for Africa. (2022, March). Nigeria bolsters laboratory capacity for antimicrobial resistance towards universal health coverage. <https://www.afro.who.int/countries/nigeria/news/nigeria-bolsters-laboratory-capacity-antimicrobial-resistance-towards-universal-health-coverage>
- World Health Organization. (n.d.). Global Antimicrobial Resistance and Use Surveillance System (GLASS). <https://www.who.int/initiatives/glass>
- Yusuff, M., Akinsola, O., Olabiyi, M., Anioke, S. C., Agbasiere, C., & Kamwesiga, J. (2025). Leveraging AI in drug and substance abuse recovery: A systematic approach to reintegration and rehabilitation for the homeless. *Journal of Medicine and Health Research*, 10(1), 20-30.
- Yusuff, T. A., Iloeje, K. F., Favour, S., & Hassan, Z. (2025). Creating quantum-powered epidemiological models enabling proactive responses to pandemics and emerging health threats. *International Journal of Scientific Research and Modern Technology*.
- Zay Ya, K., Win, P. T. N., Bielicki, J., Lambiris, M., & Fink, G. (2023). Association between antimicrobial stewardship programs and antibiotic use globally: A systematic review and meta-analysis. *JAMA Network Open*, 6(2), e2253806.