POLICY BRIEF

Environmental AMR Surveillance: The Missing Pillar of Europe's One Health Strategy

Gene Mobility · Tiered Monitoring · Wastewater Linkage · Actionable One Health Data

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Key Messages

- Environmental antimicrobial resistance surveillance remains the weakest and most fragmented pillar of Europe's One Health strategy.
- Current monitoring often measures resistant bacteria or antibiotic resistance genes without determining whether these genes are mobile, which organisms carry them, or whether they are likely to disseminate.
- Antibiotic resistance gene abundance alone is therefore insufficient for environmental risk interpretation.
- Gene mobility, especially linkage to plasmids and other mobile genetic elements, provides critical information on the potential for resistance to spread between bacteria and eventually reach pathogens.
- No single method can provide all information needed for surveillance and risk assessment.
- Europe should adopt a harmonised but flexible, tiered surveillance framework that combines broad routine screening with targeted mobility and host-context analysis.
- Surveillance should be evaluated by whether it supports decisions, interventions, and mitigation, not only by how much data it generates.

7	3-tier	Mobility	One Health
Policy recommendations for a fit-for-purpose framework	Surveillance model: routine, mobility, high-resolution	The key missing indicator in current AMR monitoring	Human, animal and environmental health bridged by data

1. The Policy Challenge

Antimicrobial resistance is a major One Health challenge because resistant bacteria and resistance genes move between humans, animals, and environmental compartments. Europe has established increasingly coordinated surveillance systems for clinical and veterinary AMR, but the environmental dimension remains poorly institutionalised.

Across Europe, environmental AMR activities differ substantially in their targets, sampling strategies, methods, governance, and funding. In many countries, environmental surveillance is mentioned in national AMR action plans but remains limited to short-term research projects, pilot studies, or isolated monitoring activities. Responsibilities are also divided between health authorities, environmental agencies, agricultural authorities, wastewater utilities, and research organisations. As a result, data are often difficult to compare across countries and are rarely integrated into a coherent One Health surveillance system.

The expansion of wastewater-based surveillance provides an important opportunity. Raw wastewater can support population-level monitoring of AMR circulating in communities, while treated effluent and receiving environments

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can provide information on environmental release, persistence, and potential dissemination. However, wastewater surveillance alone cannot capture the full environmental dimension of AMR, including agricultural runoff, industrial emissions, combined sewer overflows, surface waters, sediments, soils, and other exposure pathways.

The ONE-Bridge workshop in Dresden, "Making Environmental AMR Surveillance Fit for Purpose: Data Integration and the Ecology of Resistance," brought together researchers, practitioners, wastewater stakeholders, and policy representatives to identify how surveillance can become more useful for policy and risk management. The discussions focused on what should be monitored, how ecological context changes interpretation, how surveillance data can trigger action, and what governance and infrastructure are needed.

Monitoring abundance alone is not enough

Antibiotic resistance genes are natural components of microbial communities. Detecting an ARG in an environmental sample does not automatically imply a direct health risk. The significance of that detection depends on the gene's genetic and ecological context.

The same ARG may be relatively low risk when it is chromosomally encoded in a non-pathogenic environmental bacterium, but more concerning when it is linked to a broad-host-range plasmid or another mobile genetic element that can transfer between bacterial species. Similarly, a rare but highly mobile ARG may be more important than a highly abundant but immobile gene.

Current environmental surveillance often relies on abundance measurements. These are useful for identifying trends, hotspots, and anthropogenic enrichment, but they do not reveal whether detected genes can move between bacteria. Existing risk-ranking approaches also frequently classify ARGs according to their historical occurrence in pathogens or mobile elements, without confirming whether those same associations are present in the sample being monitored.

ARG mobility is therefore a key missing indicator. In environmental systems, an ARG may pass through several bacterial hosts before reaching a pathogen. Measuring its association with plasmids or other mobile elements provides a practical estimate of dissemination potential and can improve the interpretation of environmental AMR data.

BOTTOM LINE	*Gene abundance tells you a resistance determinant is present; gene mobility tells you whether it can spread. Only the second answer supports a risk decision. Mobility must become a routine surveillance indicator, not a specialist afterthought.*

2. A Practical Surveillance Model

No single method can provide all the information needed for environmental AMR surveillance. Scalable methods such as qPCR, ddPCR, and culture-based assays are sensitive and relatively affordable, but they provide limited information on genetic context. Metagenomic and sequencing-based approaches provide broader information but are less sensitive, more expensive, and more difficult to implement routinely. A tiered framework offers a practical solution.

Tier 1 — Routine screening

Routine monitoring should use sensitive and scalable methods to establish baselines, detect temporal changes, identify hotspots, monitor treatment and discharge trends, and compare sites and regions.

- Establish baselines and detect temporal changes
- Identify hotspots and monitor treatment and discharge trends
- Compare sites and regions using a limited panel of clinically relevant ARGs
- Include resistant indicator organisms, selected MGE markers, and relevant contextual or chemical indicators

Tier 2 — Mobility and host-context analysis

Priority samples should undergo targeted follow-up when routine screening identifies sustained increases, unusual spatial patterns, poor treatment removal, or high-risk resistance determinants. Follow-up methods may include:

- Linkage-based ddPCR and targeted amplicon sequencing

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- Isolate characterisation and short-read metagenomic analysis
- ARG-host and ARG-MGE association analysis
- Source tracking

The aim is to determine whether a signal reflects background resistance, anthropogenic enrichment, mobile resistance, or a plausible transmission pathway.

Tier 3 — High-resolution investigation

Long-read sequencing, hybrid metagenomics, plasmid reconstruction, advanced source attribution, and quantitative risk assessment should be reserved for major hotspots, emerging threats, or cases where regulatory or mitigation decisions require detailed evidence.

BOTTOM LINE	*Screen broadly, investigate selectively. A tiered system matches analytical effort to risk and policy relevance, letting routine methods flag signals and higher-resolution methods explain them — without demanding sequencing everywhere.*

3. Policy Recommendations

REC 1: Establish environmental AMR surveillance as a formal One Health pillar

Environmental surveillance should be explicitly integrated into national AMR action plans, with defined institutional responsibility, long-term funding, and measurable objectives.

REC 2: Define the purpose before choosing methods

Every surveillance activity should state the policy or management question, the environment or pathway of concern, the intended user of the data, and the action that could follow a positive signal. Monitoring without a defined decision pathway risks becoming descriptive rather than actionable.

REC 3: Move progressively beyond abundance-only monitoring

Routine abundance measurements should be retained, but priority signals should be followed by mobility and host-context analysis. Clinically relevant and mobile ARGs should receive particular attention.

REC 4: Create a harmonised European minimum framework

Europe should agree on minimum metadata requirements, quality assurance procedures, reporting standards, inter-laboratory validation, a limited common set of surveillance indicators, and common data collection repositories. Countries should remain free to add context-specific targets and advanced methods.

REC 5: Connect wastewater and environmental surveillance

Raw wastewater, treated effluent, and receiving environments should be treated as connected but distinct surveillance compartments. This would link population-level monitoring with environmental release, persistence, and intervention assessment.

REC 6: Link surveillance to action

Surveillance systems should define triggers for confirmatory sampling, source investigation, treatment optimisation, discharge reduction, exposure management, and evaluation of mitigation success. Success should be judged by whether surveillance changes decisions and reduces risk, not only by the number of samples or targets analysed.

KEY POINT	*The value of surveillance is measured in decisions taken and risk reduced — not in gigabytes generated. Every monitoring activity should be able to name the action a positive signal would trigger.*

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4. Call to Action

Europe does not simply need more environmental AMR data. It needs a coordinated surveillance system that identifies which resistance determinants can spread, where intervention is possible, and what action should follow.

The next step is to move from fragmented monitoring toward sustained, mobility-informed, and actionable One Health surveillance.

FINAL MESSAGE	*Environmental AMR is the missing pillar of Europe's One Health strategy. Abundance data alone cannot tell us what will spread. A harmonised, tiered, mobility-informed system — linked to decisions — is now needed. The methods exist. The framework is overdue.*

Basis of This Policy Brief

Outcomes of the ONE-Bridge workshop "Making Environmental AMR Surveillance Fit for Purpose: Data Integration and the Ecology of Resistance," held in Dresden, Germany, on 6–7 October 2025, and of the ONE-BRIDGE IN HEALTH Conference, held at the Conference & Cultural Center of the University of Patras, Greece, on 8–11 December 2025, within the project "One Health Nexus: Bridging Human, Animal, and Environmental Health Across Europe" (ONE-Bridge), Grant Agreement No. 101233407, co-financed by the EU4Health Programme of the European Union.

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