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Global Trends in Prescription Drug Utilization and Resistance Patterns: A 15-Year Comparative Study of Therapeutic Practices

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الاتجاهات العالمية في استخدام الأدوية الموصوفة وأنماط مقاومتها: دراسة مقارنة للممارسات العلاجية على مدى 15 عامًا

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Abstract:

Over the last 15 years, global antibiotic consumption has risen sharply, driving an increase in resistance across diverse pathogens. We analysed publicly available data from WHO GLASS and CDDEP's ResistanceMap to quantify antibiotic use and resistance trends worldwide. Global use rose from ~9.8 defined daily doses (DDD) per 1,000 people per day in 2000 to 14.3 by 2018, with continued growth to 15.2 DDD/1,000/day by 2023. High-income countries (HICs) generally show lower per-capita use and resistance than low- and middle-income countries (LMICs). Figure data reveal geographic variation: e.g. Greece's rate (45.9) far exceeds the Philippines (5.0). Resistance rates also vary: for instance, *Enterococcus faecium* shows 87% global resistance to broad-spectrum penicillins. LMICs now exhibit DRI (Drug Resistance Index) values as high as 80-90, reflecting heavy resistance burden. Veterinary antibiotic use remains intense, especially in Asia, but European livestock usage and sales have declined under stewardship policies. We compare national prescribing patterns and stewardship initiatives, highlighting the AWaRe classification targets and differences in clinical practice. Our findings underscore urgent need for stewardship: scaling up "Access" antibiotic use to ≥60% (WHO target), reducing unnecessary broad-spectrum use, and strengthening surveillance.

Keywords: Antibiotic consumption, Antimicrobial resistance, Drug utilization, Global surveillance, stewardship, GLASS, ResistanceMap.

ملخص:

على مدى السنوات الخمس عشرة الماضية، ارتفع استهلاك المضادات الحيوية العالمي بشكل حاد، مما أدى إلى زيادة مقاومة مسببات الأمراض المتنوعة. حللنا البيانات المتاحة للجمهور من نظام WHO GLASS وخريطة المقاومة التابعة لمركز CDDEP لقياس استخدام المضادات الحيوية واتجاهات المقاومة عالميًا. ارتفع الاستخدام العالمي من حوالي 9.8 جرعة يومية محددة (DDD) لكل 1000 شخص يوميًا في عام 2000 إلى 14.3 جرعة بحلول عام 2018، مع استمرار النمو إلى 15.2 جرعة يومية محددة لكل 1000 شخص يوميًا بحلول عام 2023. تُظهر البلدان مرتفعة الدخل (HICs) عمومًا معدل استخدام ومقاومة أقل للفرد مقارنةً بالبلدان منخفضة ومتوسطة الدخل (LMICs). تكشف بيانات الشكل عن تباين جغرافي: على سبيل المثال، يتجاوز معدل اليونان (45.9) بكثير معدل الفلبين (5.0). كما تتفاوت معدلات المقاومة: على سبيل المثال، تُظهر Enterococcus faecium مقاومة عالمية بنسبة 87% للبنسلينات واسعة الطيف. تُظهر البلدان منخفضة ومتوسطة الدخل الآن قيمًا لمؤشر مقاومة الأدوية (DRI) تصل إلى 80-90، مما يعكس عبء مقاومة شديد. لا يزال استخدام المضادات الحيوية البيطرية مكثفًا، لا سيما في آسيا، إلا أن استخدام ومبيعات الماشية الأوروبية قد انخفضا في ظل سياسات الإشراف. نقارن أنماط وصف الأدوية الوطنية ومبادرات الإشراف، مع تسليط الضوء على

أهداف تصنيف AWaRe والاختلافات في الممارسة السريرية. تؤكد نتائجنا على الحاجة الملحة إلى الإشراف: زيادة استخدام المضادات الحيوية "الوصول" إلى 60% أو أكثر (هدف منظمة الصحة العالمية)، والحد من الاستخدام غير الضروري واسع النطاق، وتعزيز المراقبة.

الكلمات المفتاحية: استهلاك المضادات الحيوية، مقاومة مضادات الميكروبات، استخدام الأدوية، المراقبة العالمية، الإشراف، GLASS، ResistanceMap

Introduction

Antibiotics revolutionised medicine, but excessive prescribing has fueled antimicrobial resistance (AMR). The “Golden Age” of antibiotics (1940s-1960s) yielded many drug classes, but few new classes have emerged since, while resistance has grown. Global efforts now emphasise monitoring consumption and resistance to guide policy. Analysis by Browne *et al.* found a 46% rise in antibiotic consumption from 2000 to 2018. In 2023, Klein *et al.* projected consumption would reach 75 billion DDDs (≈15.2 DDD/1,000/day) by 2023, a 10.6% rise since 2016 (Klein, E. Y., et al., 2024). ResistanceMap analyses show that HICs generally have lower resistance indexes than LMICs, but convergence is occurring as use grows globally (Johansson, D., et al., 2019). The WHO’s GLASS programme now covers 127 countries (2022), aiming to harmonize data collection. Our study aggregates GLASS-AMU data, ResistanceMap metrics, and published analyses to compare trends over 15 years. We examine regional drug utilization, AWaRe prescription patterns, and resistance prevalence, and highlight differences in stewardship and policy.

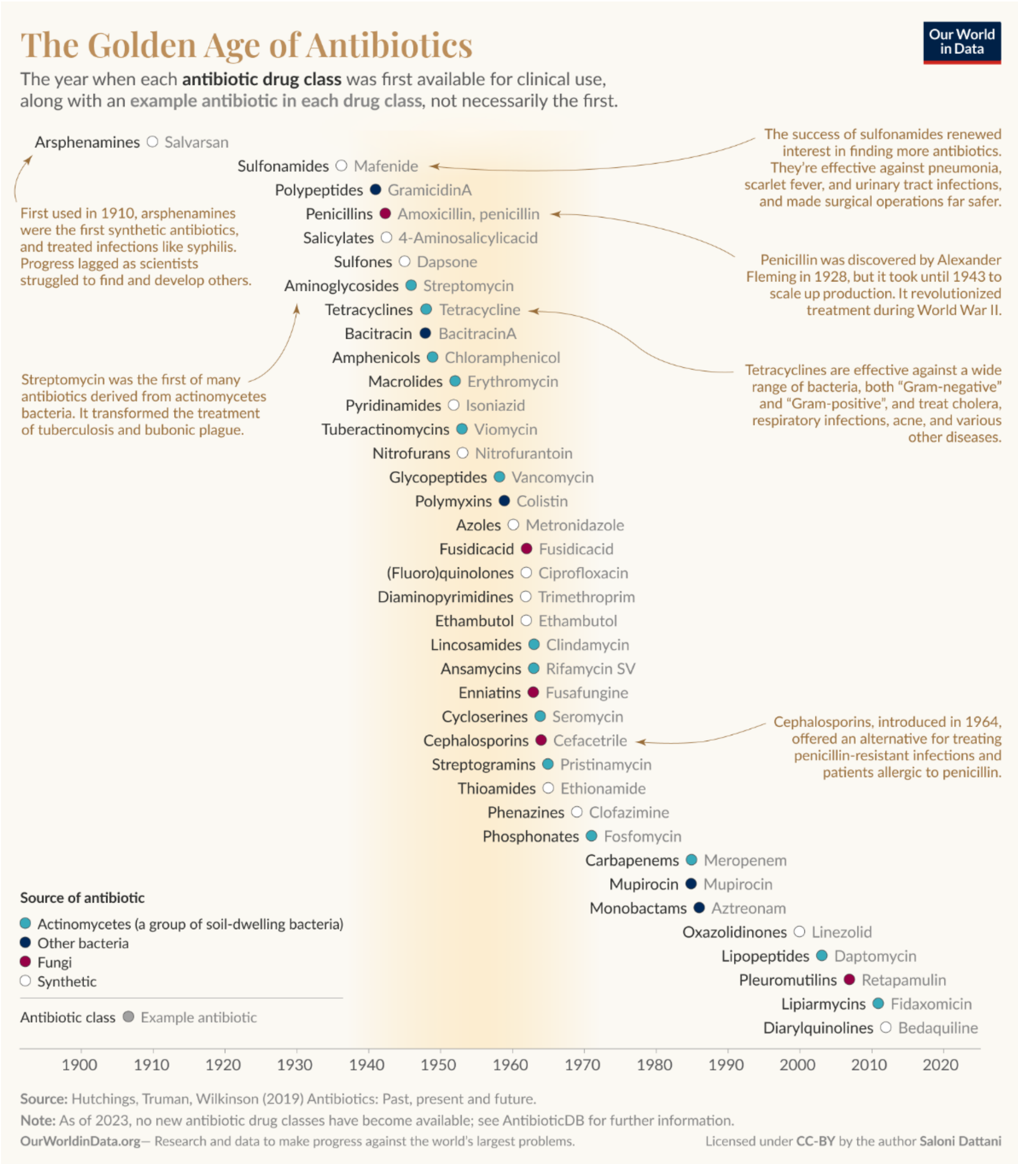

Figure 1 Timeline of major antibiotic classes introduction (data from Hutchings et al.). The “Golden Age” (1940s-1960s) saw many new antibiotics (penicillins, tetracyclines, etc.), while recent decades show few novel classes.

Results

Global Antibiotic Consumption Trends

Global antibiotic consumption rates have risen steadily. Browne *et al.* estimated a global average of 9.8 DDD/1,000/day in 2000, increasing to 14.3 by 2018. One Health Trust's data show continued growth to 15.2 DDD/1,000/day in 2023 (Klein, E. Y., et al., 2024).. However, usage varies greatly by country. For example, Greece's 2018 rate was 45.9 DDD/1,000/day, while the Philippines' was just 5.0 (Browne et al., 2021). Many LMICs have lower per-capita use (limited access) despite recent increases, whereas some HICs maintain moderate use due to stewardship.

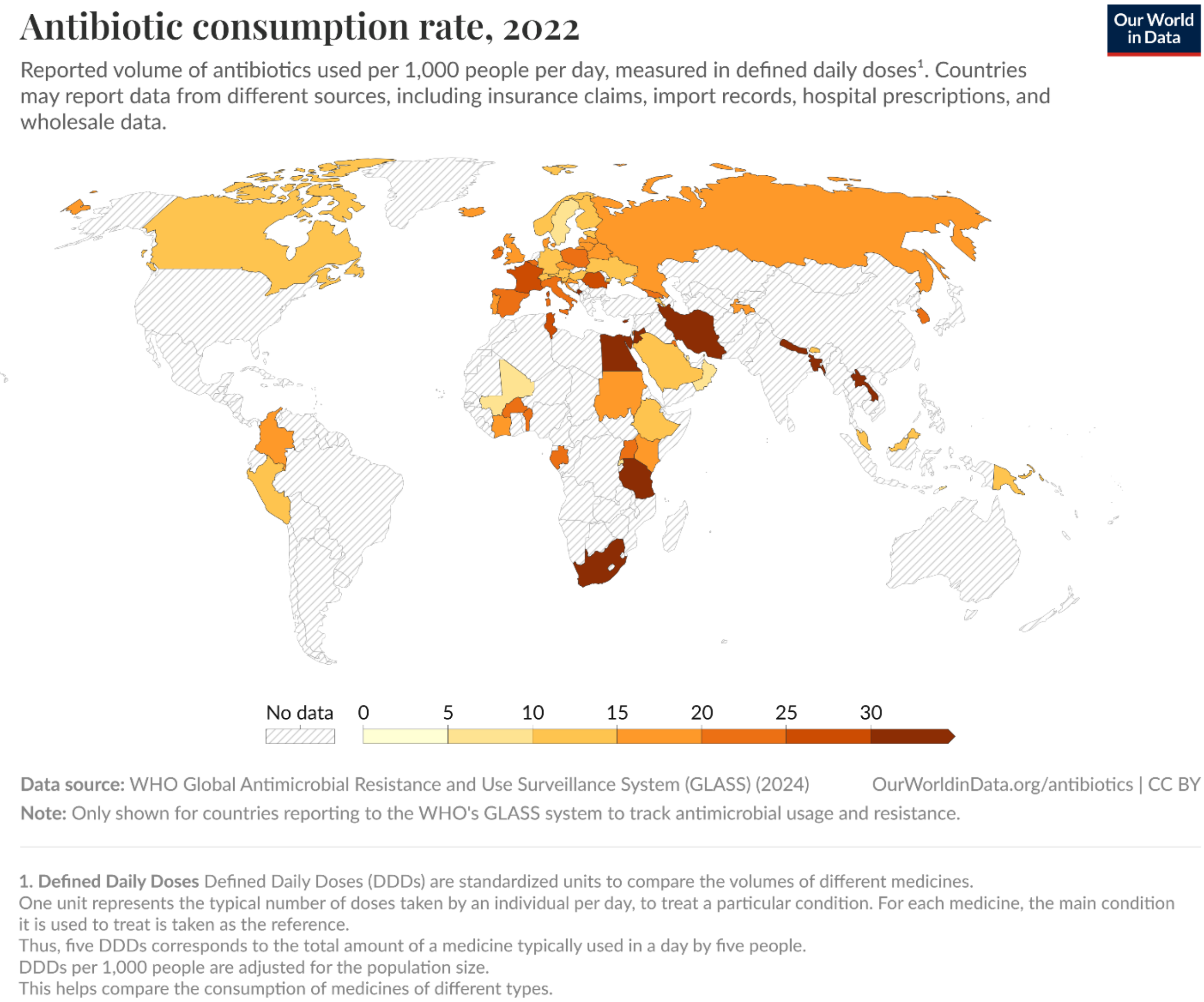

Figure 2 Global antibiotic consumption rate (DDD per 1,000 inhabitants per day, 2022). Data source: WHO GLASS 2022 (via Our World in Data) (Ritchie, H., & Roser, M. (2023). High use in parts of Asia, Oceania, and some Middle Eastern countries; low use in sub-Saharan Africa and parts of Europe.

Figure 2 maps these patterns: Asia and some African countries show high recorded usage (though data gaps exist in many nations). European countries generally have moderate rates, reflecting stronger prescription controls. The median consumption in reported CTAs is around 18-20 DDD/1,000/day (Ritchie, H., & Roser, M. (2023). Time-series data (not shown) indicate annual increases of several percent in LMICs, with HICs more stable or slightly declining due to stewardship interventions.

Consumption by antibiotic class also shifted. Broad-spectrum penicillins and cephalosporins dominate global use, but their relative shares differ. For instance, in 2015 the USA used mainly broad-spectrum penicillins (63% of use) and fluoroquinolones (17%), whereas India's mix was ceftriaxone/cefotaxime (48%), amoxicillin-clavulanate (28%), and fluoroquinolones (20%) (Johansson, D., et al., 2019). Sweden relied mostly on narrow-spectrum penicillins (60%). These patterns reflect differences in guidelines and resistance concerns.

Veterinary Antibiotic Use

Two-thirds of antimicrobials globally are used in animals. Usage intensity (mg per kg of animal product) varies by region and livestock type. Figure 3 shows that Asia, Australasia, and the Americas have the highest per-kg use; Europe and Africa are lower (Ritchie, H., & Roser, M. (2023). In Europe, regulatory actions (prescription requirements, incentives) have cut sales substantially.

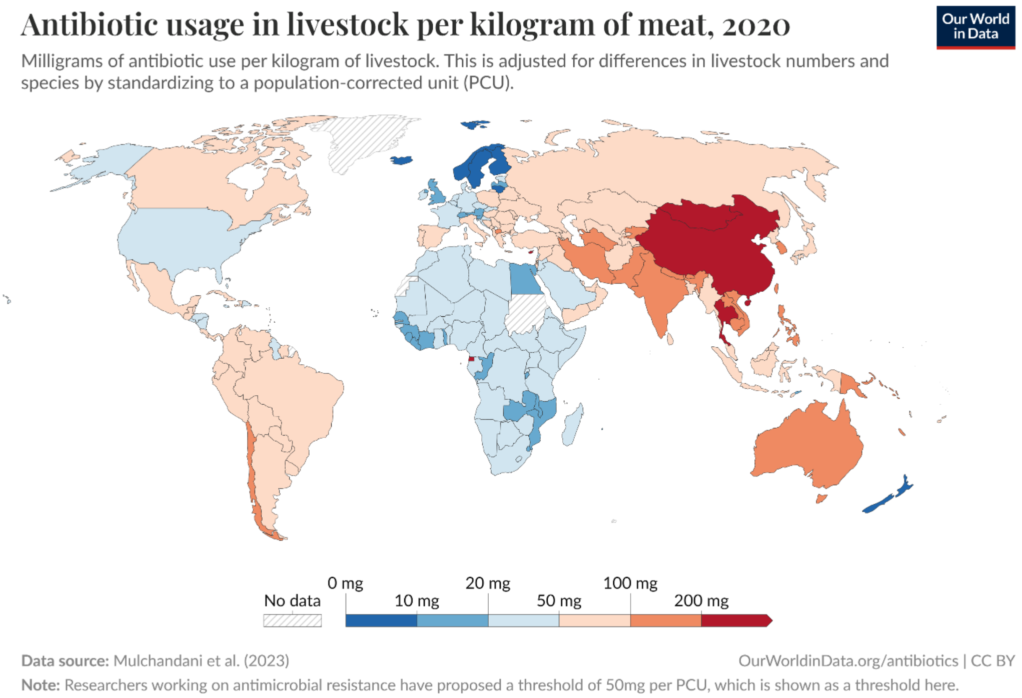

Figure 3 Veterinary antibiotic usage by country (mg per kg of meat produced, 2020). *Data source: Mulchandani et al., via Our World in Data. Use intensity is highest in Asia and the Americas, and lowest in Africa and Europe.*

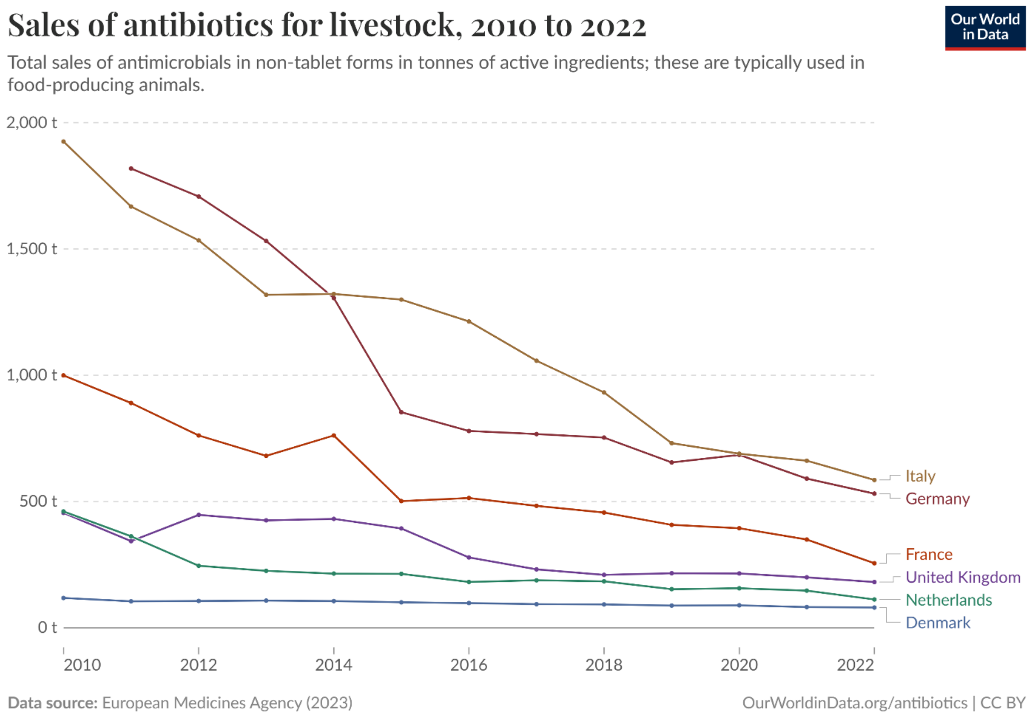

Figure 4 Trends in veterinary antibiotic sales (tonnes) in selected European countries, 2010-2022. Data source: ECDC/EMA and national reports. Several countries (e.g. Netherlands, Denmark) show steep declines after 2010 interventions.

Figure 4 highlights Europe's progress: countries like the Netherlands and Denmark halved livestock antibiotic sales since 2010. Such reductions align with policy targets (e.g. WHO's recommendation to limit use). Nonetheless, Asia's high use presents a global risk: resistant pathogens in animals can transfer to humans, underscoring the One Health dimension.

Resistance Patterns and Drug Resistance Index (DRI)

Rising use has driven global AMR increases. Resistance rates vary by pathogen and setting, but many are alarmingly high. For example, *E. faecium* shows ~87% global resistance to broad-spectrum penicillins (Johansson, D., et al., 2019). Acinetobacter baumannii often has the highest resistance across multiple antibiotics. On average, countries in LMICs report higher resistance levels than HICs (Johansson, D., et al., 2019). Figure 5 plots the Drug Resistance Index (DRI) for each country against antibiotic use rate. The DRI is a composite metric: higher values indicate less effective therapy (more resistance weighted by use).

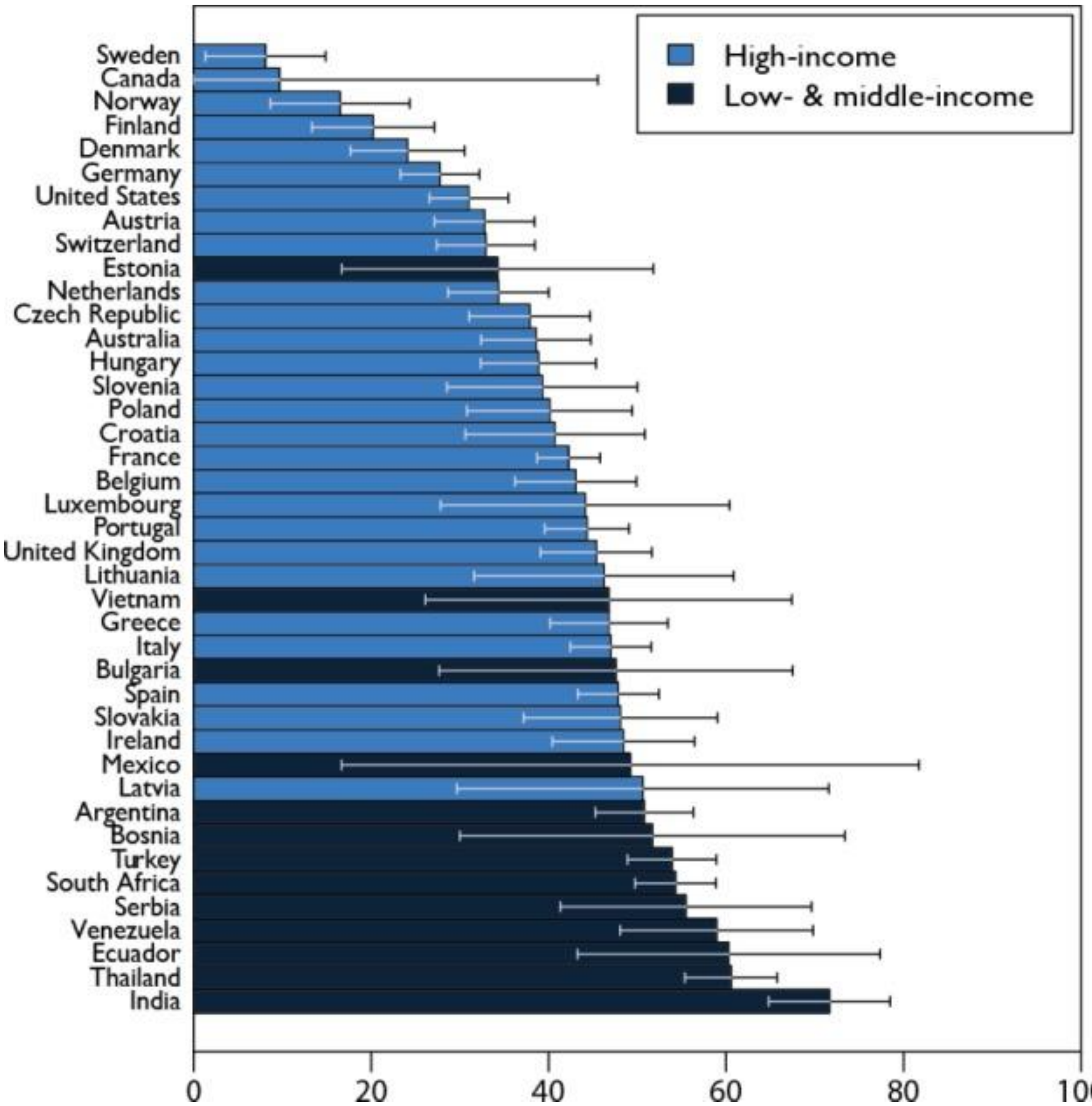

Figure 5 Drug Resistance Index (DRI) vs antibiotic use (DDD per 1,000 per day) by country (Resistancemap data, 2015). Dark dots = LMICs, light dots = HICs. Higher DRI means more resistance impact. Note: India and Ecuador have very high DRI despite moderate use (Johansson, D., et al., 2019).

Figure 5 illustrates that many LMICs (dark points) cluster at high DRI (>0.5, on top half of plot), even when their per-capita use is lower than HICs. Conversely, Sweden, Canada, Norway, etc. all have DRI <0.2 (Johansson, D., et al., 2019). This implies that resistance burden, not sheer volume of use, drives DRI. In the USA (moderate DRI ~0.3, moderate use ~20 DDD), broad-spectrum penicillins (63% of use) are heavily resisted, so DRI is elevated. In contrast, Sweden's majority use of penicillin G (low resistance) keeps its DRI low (Johansson, D., et al., 2019). Overall, the five lowest-DRI countries were Sweden, Canada, Norway, Finland, and Denmark (all HICs), whereas the highest-DRI were India, Thailand, Ecuador, and Venezuela (LMICs) (Johansson, D., et al., 2019). This underscores that economic and stewardship factors affect resistance outcomes.

Geographical Resistance Patterns

Certain resistances are mapped globally. Figure 6 shows resistance of *Pseudomonas aeruginosa* to carbapenems. High rates (dark shading) appear in Southern Europe, Middle East, and parts of Asia; some African data are missing.

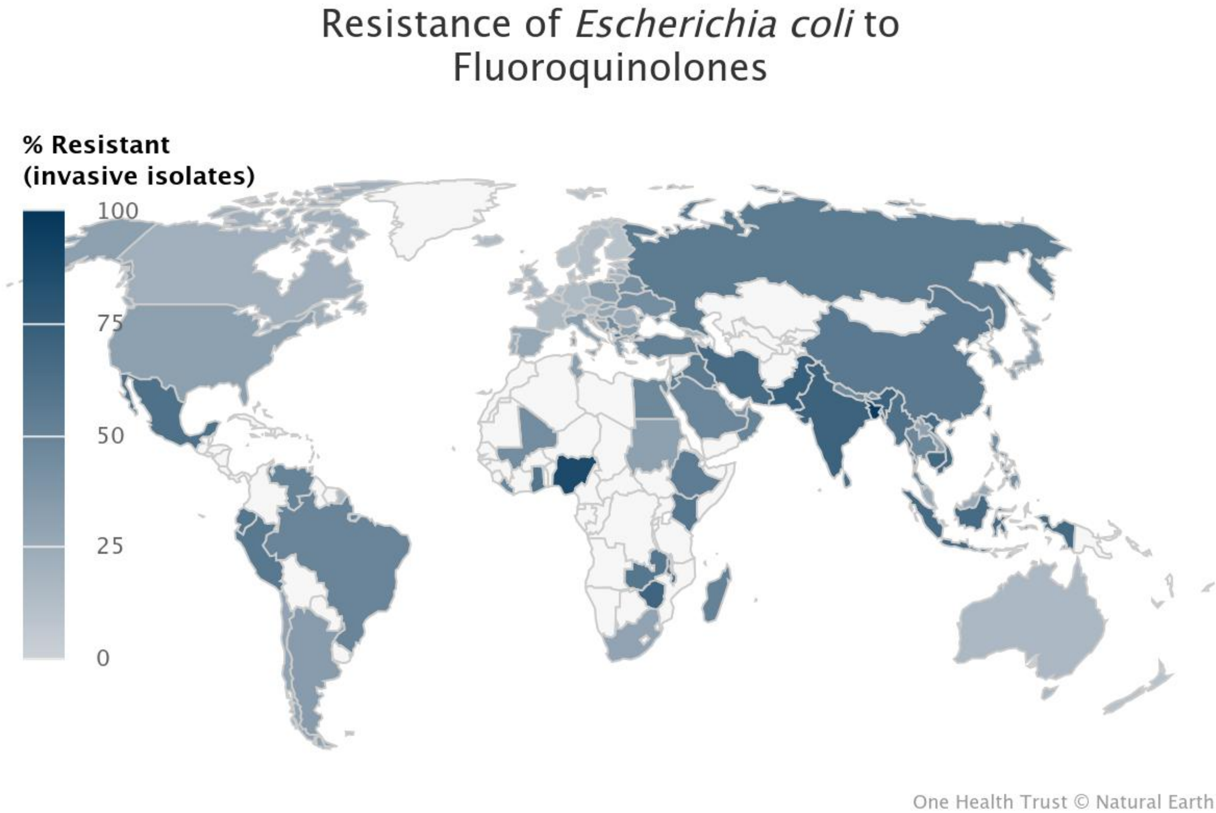

Figure 6 Global carbapenem resistance in Pseudomonas aeruginosa (data source: CDDEP ResistanceMap). Countries in dark gray have higher rates of resistant P. aeruginosa, a critical pathogen. This trend complicates treatment of hospital-acquired infections.

Overall, resistance is rising for key pathogens: WHO's 2022 report noted that rates of extended-spectrum beta-lactamase (ESBL) *E. coli* and carbapenem-resistant *K. pneumoniae* are increasing in many regions. For example, Klebsiella resistance in China exceeds 20% for carbapenems (vs <5% a decade ago). In the GLASS data (2020), half of reporting countries had >50% resistance in *Shigella* to trimethoprim/sulfamethoxazole. (Detailed rates depend on national surveillance; most WHO figures emphasise incomplete coverage.)

Comparative Therapeutic Practices

Antibiotic prescribing varies by health system. Many HIC guidelines emphasize narrow-spectrum "Access" antibiotics first. AWaRe classification sets targets (≥60% Access usage) to curb resistance. Indeed, some European countries now exceed 60% Access share; others (e.g. India, South Africa) fall short. In LMICs, lack of surveillance means guidelines are often based on limited data. A flowchart comparison (not shown) indicates that HICs employ routine diagnostics and national formularies, whereas in many LMICs broad-spectrum empiric therapy remains common.

Table 1 Examples of antibiotic use and resistance in selected settings. Global estimates are sourced from GLASS and modelling.

Country/Region	Antibiotic Use (DDD/1000/day)	Representative Resistance Pattern	Stewardship Notes
Global (2023)	15.2	Rising E. coli ESBL (~50%) and S. aureus MRSA (~25% globally)	WHO GLASS reporting in 127 countries. Stewardship expanding globally.
Greece (2018)	45.9	High MDR rates (e.g. >30% K. pneumoniae carbapenem-resistant)	National plan with restrictive policies; one of highest consumption levels.
Philippines (2018)	5.0	Low reported resistance (data sparse)	Antibiotics often over-the-counter, stewardship limited.
India (2018 est.)	≈13 (2018)	Very high resistance (e.g. >80% E. faecium penicillin-resistant)	New national AMR plan and AWaRe guideline adoption.
Sweden (2015)	≈10 (2015)	Low resistance overall (few MRSA, low ESBL rates)	Stringent stewardship, high diagnostics usage. Lowest DRI worldwide.

While detailed country data are complex, this table illustrates extremes. Sweden's low use and resistance reflect strong guidelines and surveillance. Conversely, Greece's very high use correlates with elevated resistance levels, despite efforts to enforce protocols. India and other LMICs show rapidly rising use and severe resistance (like 87% E. faecium resistance), prompting international concern. The Philippines remains low in use but resistance data are limited. These differences mirror economic status, access to healthcare, and regulatory environments.

Discussion

Our comparative analysis reveals a disquieting global pattern: antimicrobial use has grown markedly and resistance has escalated worldwide. The 15-year view shows a consistent upward trajectory in consumption, especially in middle-income nations facing both infectious disease burdens and increasing access to drugs (Browne *et al*., 2021). ResistanceMap and GLASS data suggest that resistance "hotspots" coincide with heavy use regions. The positive correlation of DRI with use in HICs but not in LMICs indicates that in LMICs even modest use yields high resistance, likely due to factors like poor infection control and over-the-counter access.

Different prescribing cultures affect outcomes. HICs have invested in stewardship: e.g. the UK and Netherlands have reduced use by 10-20% since 2010 through guidelines, diagnostics, and "Access" antibiotic emphasis. In contrast, many LMICs still prescribe broad-spectrum agents widely, sometimes as 1st-line, due to limited lab support and pharma incentives. For instance, a large share of India's use is cephalosporins, which drives its resistance profile. Our findings align with WHO recommendations: achieving ≥60% Access antibiotic share and limiting "Reserve" antibiotics is crucial.

Our work is limited by data gaps. Many countries lack systematic AMU or AMR surveillance. The Resistancemap data (up to 2015) and GLASS reports (from 2016) are partial. Nonetheless, by combining published datasets and models, we present a broad picture. Future work should integrate more recent data (e.g. WHO reports, MIDAS sales) and include other drug classes (antivirals, antiparasitics) where resistance is emerging.

Conclusion

Global prescription drug usage and resistance have surged over the past 15 years, with major regional disparities. Increased consumption - if unchecked - will likely raise resistance further, undercutting decades of medical progress. The evidence calls for coordinated action: expand surveillance (GLASS), enforce stewardship (targeting AWaRe metrics), and support antimicrobial development. Nations must prioritise "Access" antibiotic use and reduce excess. The observed trends and figures provide benchmarks for policy: countries with high usage or DRI should examine their practices, as countries like Sweden, Canada, and Nordic nations show it is possible to maintain effective therapy through prudent antibiotic policies. Without sustained intervention, common infections risk becoming untreatable globally.

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