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Antimicrobial Resistance: Emerging Challenges and Innovative Approaches in Clinical Practice

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Abstract
Background: *Antimicrobial resistance (AMR) is one of the biggest health problems in the world today. It threatens infection treatments and decades of progress in medicine. AMR is caused by overuse, abuse, and wrong prescription of antibiotics in medicine, farming, and animal care. This leads to the development of MDR, XDR, and pan-resistant bacteria that render standard treatments useless.*
Objective: *This research looks at the current state of AMR, the main microbe dangers, the factors that affect it, and diagnostic, therapeutic, and policy options that can be used in the real world to fight resistance.*
Methods: *A thorough review of all the studies that have been published, global surveillance reports (e.g., WHO, CDC), and new clinical guidelines from 2015 to 2025 were done. The studies were mainly about resistance trends, high-priority infections, and new ways to treat them.*
Results: *AMR problems include Gram-negative bacteria that are resistant, infections that do not respond well to treatment, and new drug research that stops moving forward. There are many things that could be done, such as rapid molecular diagnostics, antimicrobial management, bacteriophage therapy, CRISPR-based tools, and narrow-spectrum drugs.*
Conclusion: *AMR is a threat to health and professional care around the world. To keep antibiotics working, we need better diagnostics, targeted medicines, regulatory changes, global monitoring, and education for both doctors and patients.*
Keywords: *Antimicrobial resistance, multidrug-resistant pathogens, clinical management, antimicrobial stewardship, novel therapies, rapid diagnostics.*

INTRODUCTION

Antimicrobial resistance (AMR) has grown over the past few years and is now a big public health issue. More and more bacterial, viral, fungal, and parasitic strains are becoming immune to treatment. This makes it harder to get rid of infections that used to be easy to treat. The World Health Organization (WHO) says that drug-resistant diseases could kill up to 10 million people every year by 2050 if nothing is done. The WHO sees AMR as a big threat to global health, food security, and economic growth. Resistance is mostly caused by using too many antibiotics or not using them correctly in medicine, farming, and animal care. Other things that make the problem worse are not enough steps to prevent infections, not enough diagnostic tools, and the fact that antibiotics can be bought without a prescription in many places. Clinically, antibiotic resistance has made the healthcare system more stressed by making it more likely for people to die, get sick, and stay in the hospital longer. Multidrug-resistant (MDR) and widely drug-resistant (XDR) bacteria, viruses, and fungi are becoming more common. These organisms cause many common infections, such as those in the urinary tract, respiratory tract, bloodstream, and after surgery. At the same time, the process of making new antibiotics has slowed down a lot because of their high costs, problems with regulations, and the fact that drug companies do not have any financial motivation to do so. Because the problem is so big and complicated, we need to quickly diagnose it, use phage therapy, develop CRISPR-based antibiotics, use precision medicine methods, and put money into antimicrobial stewardship. The main goals of this review are to look at the constantly changing threats that AMR poses and show the newest clinical and technical solutions that are being used to lessen its effects in modern healthcare systems.

REVIEW OF LITERATURE

(Roca et al. n.d.) studied "*The global threat of antimicrobial resistance: science for intervention* In the recent decade, the proportion and absolute number of multi-antibacterial-resistant bacteria has skyrocketed. Multidrug-resistant bacteria are a developing global illness and public health issue. Famous experts from policy makers, public health authorities, regulatory agencies, pharmaceutical companies, and the scientific community met at the B-Debate to review the global threat of antibiotic resistance and develop a multifaceted strategy to fight it. We summarize the B-Debate participants' views on antimicrobial resistance in animals, the food chain, the community, and healthcare, as well as the role of the environment and the development of novel diagnostic and therapeutic strategies, providing expert recommendations to combat the global threat. Novel Microbes and Infections Copyright 2015 Authors. Publisher: Elsevier Ltd. for European Society of Clinical Microbiology and Infectious Diseases.

(Vasilios Papastergiou, Sotirios D Georgopoulos, and Stylianos Karatapanis Vasilios 2014) studied *Treatment of Helicobacter pylori infection: Meeting the challenge of antimicrobial resistance* essential for treating peptic ulcer disease and stomach cancer. High incidence of H. pylori antibiotic resistance makes clarithromycin-based triple treatments unsuitable for empiric usage, unless local resistance is <20%. Clarithromycin resistance is being addressed by alternative methods, some of which are already in use. These include (1) adoption of novel, more effective empirical treatments: bismuth quadruple, sequential, non-bismuth quadruple (concomitant), dual-concomitant (hybrid), and levofloxacin-based regimens, the latter mostly used as second-line/rescue options; (2) perspectives for a susceptibility-guided (tailored) therapeutic approach based on culture-free molecular testing methods; and (3) adjunct use of probiotics to improve eradication rates. This article reviews existing and emerging H. pylori infection treatment techniques, focusing on antibiotic resistance.

(Brig A.K. Jindal 2014) studied *Antimicrobial resistance: A public health challenge* Globally, antimicrobial resistance is a problem. Though evolutionary, it is promoted by bad human behavior. Since 1940, it has been a developing concern. Many novel antimicrobials are ineffective against vulnerable species. Health care administrators worldwide face this dilemma, aggravated by the discovery void in antibiotic research. If steps are not taken now, a therapeutic dead end is possible. This study describes the AMR pandemic from a public health perspective and proposes collaborative solutions.

(Spellberg et al. 2015) studied Novel Approaches Are Needed to Develop Tomorrow's Antibacterial Therapies Even though new medications are scarce, antibiotic resistance is rising. Every antibiotic user influences the efficacy of antibiotics for everyone else. Thus, antibiotic crisis responses must be societal. Antibiotic market failure is caused by scientific hurdles to discovering and producing new antibiotics, adverse economics, and a hostile regulatory environment. New antibiotic screening methods are scientific solutions. Innovative treatments that disarm bacteria without killing them or regulate the host inflammatory response to infection will diminish selective pressure and resistance emergence. New business models are needed to fund antibiotic development throughout economic transition. Finally, regulatory reform is essential for practical, robust, and clinically meaningful clinical development programs. Pulmonary and critical care experts can greatly impact antibiotic availability. Encourage molecular diagnostic tests to allow pathogen-targeted, narrow-spectrum antibiotic therapy, use short rather than unnecessary long course therapy, reduce inappropriate antibiotic use for probable viral infections, and reduce infection rates to preserve antibiotics for future generations.

(Ferri et al. 2016) studied *Antimicrobial Resistance: A Global Emerging Threat to Public Health Systems* Over the past two decades, antimicrobial resistance (AMR) has threatened public health systems worldwide. After the discovery of the first antibiotics that consistently improved human health, the overuse and abuse of antimicrobials in veterinary and human medicine has hastened the global spread of AMR. This study provides a detailed overview of AMR epidemiology, focusing on food-producing animals and humans, and EU and global legal frameworks and regulations. AMR challenges can be addressed by designing more effective farm-level preventive measures to reduce antimicrobial use, developing novel antimicrobials, strengthening AMR surveillance systems in animal and human populations, improving knowledge of resistant bacteria and genes, and raising stakeholder awareness of the prudent use of antibiotics in animal production and clinical settings. Due to the worldwide character of AMR and the

fact that bacterial resistance does not recognize barriers and can spread to people and the environment, the essay concludes with holistic advice for diverse stakeholders.
(S. Allcock 2017) studied *Antimicrobial resistance in human populations: challenges and opportunities* AMR is a global health issue. AMR can emerge naturally or be selected for by clinical and veterinary antimicrobial exposure. The burden, distribution, and determinants of AMR at the population level remain poorly understood despite increased global attention. We emphasize population-based approaches to examine the link between antibiotic usage and AMR in humans and animals. These approaches are needed to better understand AMR's formation and spread to drive prevention, detection, and management measures and support the sustainable use of antimicrobials in healthcare.
(Moh Aijaz et al. 2023) studied *Antimicrobial Resistance in a Globalized World: Current Challenges and Future Perspectives* AMR is a growing global health concern that affects public health, agriculture, and economies. This review paper critically evaluates AMR's existing and future problems in our interconnected and globalized society. The use of antimicrobials in healthcare, agriculture, and livestock has caused disease resistance. We examine the many causes of AMR, including antibiotic abuse, insufficient surveillance, and the rapid spread of resistance genes through worldwide travel and trade. AMR threatens antibiotic efficacy, making common infections untreatable and undermining contemporary medicine. The urgent necessity for worldwide collaboration to address AMR is stressed in this research. We also explore researching new antibiotics, improving stewardship programs, and encouraging responsible antibiotic use in healthcare and agriculture. To comprehensively address AMR, we emphasize worldwide policy cooperation, data exchange, and awareness initiatives. This review concludes that AMR is a global issue aggravated by globalization. However, sustained efforts and a diversified approach can reduce resistance and preserve antibiotic efficacy for future generations.
(Teresa M. Coque et al. 2023) studied *Antimicrobial Resistance in the Global Health Network: Known Unknowns and Challenges for Efficient Responses in the 21st Century Teresa* Modern global health challenges include antimicrobial resistance (AMR). AMR's globalization mirrors the healthcare system's scientific, technological, and organizational progress and 100 years' socioeconomic changes. Most AMR knowledge comes from large healthcare institutions in high-income countries and is scattered in studies on patient safety (infectious diseases), transmission pathways and pathogen reservoirs (molecular epidemiology), population-level prevalence (public health), management and cost (health economics), cultural issues (community psychology), and historical events. There is little communication between AMR creation, spread, and evolution factors and stakeholders (patients, clinicians, public health professionals, scientists, economic sectors, and funding agencies). This study has four complementary parts. The first discusses the socioeconomic factors that have built the current Global Healthcare system, the scientific framework in which AMR has traditionally been approached in such a system, and the novel scientific and organizational challenges of the fourth globalization scenario. The second discusses rethinking AMR in public and global health. In the third section, we review the unit of analysis (the what and the who) and the indicators (the operational units of surveillance) used in AMR and discuss the factors that affect the validity, reliability, and comparability of the information to be applied in various healthcare (primary, secondary, and tertiary), demographic, and economic settings. Finally, we compare and contrast stakeholders' goals and the gaps and obstacles of AMR prevention at different levels. In summary, this is a comprehensive but not exhaustive revision of the known unknowns about how to analyze host, microbe, and hospital patch heterogeneities, the role of surrounding ecosystems, and the challenges they pose for surveillance, antimicrobial stewardship, and infection control programs, the traditional cornerstones for controlling AMR in human health.
(Ponzo et al. 2024) studied *The Antimicrobial Resistance Pandemic Is Here: Implementation Challenges and the Need for the One Health Approach Elena* The concern of antibiotic resistance extends beyond human health to animal welfare and environmental sustainability. Drug-resistant bacteria can spread at the human–animal–environment interaction due to improper antibiotic usage, sanitation, and management. The documented presence of antimicrobials in agriculture, veterinary medicine, and human medicine has convinced all stakeholders of the need to contribute to the development of a One Health approach, which recognizes the interrelationships between animals, humans, and their environments and the need to

adopt a common strategy to limit bacterial antimicrobial resistance. Although several nations have integrated surveillance systems to track antibiotic use and antimicrobial resistance, data suggest that antibiotic usage in humans, animals, and the environment is rising worldwide. So, antibiotic-resistant bacteria are becoming a perennial issue. This analysis covers all the steps needed to ensure global health security.

(Francesco Branda 2024) studied *Implications of Artificial Intelligence in Addressing Antimicrobial Resistance: Innovations, Global Challenges, and Healthcare's Future* Due to complicated interplay between bacterial genetic variables and extrinsic circumstances like antibiotic overuse, antibiotic resistance threatens worldwide public health. AI offers novel solutions to this challenge. AI can identify resistance signals in genomic data, enabling early interventions. AI-powered decision support systems can also prescribe the most effective antibiotics based on patient data and area resistance tendencies. AI can speed medication research by predicting chemical efficacy and finding antibacterial agents. Although progress has been achieved, data quality, model interpretability, and real-world deployment remain problems. AI combined with synthetic biology and nanomedicine could prevent and mitigate antimicrobial resistance, preserving antibiotic efficacy for future generations.

(Manuela Oliveira et al. 2024) studied *An Overview of the Recent Advances in Antimicrobial Resistance*" Due to complicated interplay between bacterial genetic variables and extrinsic circumstances like antibiotic overuse, antibiotic resistance threatens worldwide public health. AI offers novel solutions to this challenge. AI can identify resistance signals in genomic data, enabling early interventions. AI-powered decision support systems can also prescribe the most effective antibiotics based on patient data and area resistance tendencies. AI can speed medication research by predicting chemical efficacy and finding antibacterial agents. Although progress has been achieved, data quality, model interpretability, and real-world deployment remain problems. AI combined with synthetic biology and nanomedicine could prevent and mitigate antimicrobial resistance, preserving antibiotic efficacy for future generations.

(Tolulope Olagoke Kolawole et al. 2025) studied *"Innovative Strategies for Reducing Antimicrobial Resistance: A Review of Global Policy and Practice"* The worldwide health concern of antimicrobial resistance (AMR) threatens antibiotics and other antimicrobials. The abuse and overuse of antibiotics in healthcare, agriculture, and animal husbandry has accelerated disease resistance, increasing morbidity, death, and economic costs. This paper critiques global AMR regulations and best practices and proposes creative, concrete solutions. The study examines the efficacy of national and international AMR action plans, including the WHO-GAP and country-specific frameworks like the U.S. National Action Plan for Combating Antibiotic-Resistant Bacteria and the European One Health Action Plan against AMR. Regulatory measures, antibiotic stewardship programs, surveillance systems, and public awareness efforts for responsible antimicrobial use are assessed. Precision medicine for targeted antimicrobial therapies, AI and big data analytics for early resistance detection, and novel antibiotic alternatives like bacteriophages and antimicrobial peptides are key innovations in AMR reduction. Rapid diagnostic techniques and blockchain-based supply chain monitoring may improve antimicrobial governance and eliminate counterfeit drugs. AMR policy implementation is hindered by regulatory fragmentation, global cooperation, and economic constraints. The review emphasizes the need for government, healthcare, pharmaceutical, and agricultural collaboration to enforce stricter antimicrobial regulations, promote new treatment research, and improve infection prevention. Policy reforms, technology advances, and public participation are needed to reduce AMR growth, according to findings. Enhancing surveillance networks, rewarding antibiotic research, and enforcing antibiotic stewardship across all sectors can drastically reduce antimicrobial overuse and resistance. This evaluation guides policymakers and stakeholders in creating sustainable, evidence-based AMR mitigation solutions.

Research Objectives

- To examine the current global trends and burden of antimicrobial resistance (AMR) in clinical and community settings, with an emphasis on high-priority pathogens.
- To analyze the underlying mechanisms of antimicrobial resistance at the molecular and cellular levels, including genetic transfer, enzymatic degradation, efflux pumps, and biofilm formation.

- To identify and evaluate the key factors contributing to the rise of AMR, such as irrational antibiotic use, poor infection control practices, and agricultural overuse.
- To review the clinical consequences of AMR, including its impact on patient outcomes, healthcare costs, and the safety of medical procedures.
- To assess the effectiveness of antimicrobial stewardship programs (ASPs) in various healthcare settings, particularly in low- and middle-income countries.

3. Mechanisms of Antimicrobial Resistance

Antimicrobial resistance (AMR) means that bacteria, viruses, fungus, and parasites stop responding to medicines that used to kill them. Bacteria are the most important clinical drivers to AMR. They can become resistant through natural traits, genetic mutation, or horizontal gene transfer. To plan treatments, make new drugs, and stop infections, it is important to understand these routes.

1 Enzymatic Drug Inactivation

Making drug degradation enzymes is one of the most common ways that bacteria become resistant to antibiotics. β-lactamases, for example, break down penicillins and cephalosporins. There are not many treatments that can be used to treat Gram-negative bacteria that have extended-spectrum β-lactamases (ESBLs), AmpC β-lactamases, or carbapenemases (e.g., KPC, NDM).

2 Alteration of Drug Targets

Antibiotics can not work if bacteria change the target spot or add enzymes that do just that. β-lactam resistance is caused by changes in penicillin-binding proteins (PBPs), and fluoroquinolone resistance is caused by changes in DNA gyrase or topoisomerase IV. The erm gene changes the 23S rRNA subunit in Gram-positive bacteria, which makes them resistant to macrolides.

3 Efflux Pumps

Efflux pumps work hard to get rid of antimicrobials from bacterial cells before they get to their target. Transport proteins can be specific to a class of drugs or immune to many drugs. Some well-known examples are the AcrAB-TolC system in E. coli and the MexAB-OprM pump in Pseudomonas aeruginosa.

4 Reduced Membrane Permeability

The top membrane porins of Gram-negative bacteria let medicines get inside. Changing porins, like OmpF in E. coli, makes it harder for drugs to work, especially β-lactams, which leads to tolerance. β-lactamase production and this process often happen at the same time.

5 Biofilm Formation

Antimicrobials can not kill biofilm bacteria as well as they can kill planktonic cells. Biofilms create walls that change the pH and nutrient gradients to stop antibiotics from penetrating and metabolic activity, which makes medications less effective. Biofilms are made by Staphlococcus aureus, Pseudomonas aeruginosa, and E. faecalis.

6 Target Bypass or Replacement

Antibiotic-resistant bacteria get around metabolic pathways or get enzymes that do not get damaged by antibiotics. Trimethoprim-sulfamethoxazole resistance can be caused by dihydropteroate synthase or dihydrofolate reductases that are not sensitive to drugs.

7 Horizontal Gene Transfer (HGT)

Resistance genes are often shared between bacteria through **horizontal gene transfer mechanisms**, such as:

- **Conjugation** (via plasmids)
- **Transformation** (uptake of free DNA)
- **Transduction** (via bacteriophages)

Multidrug resistance (MDR) spreads quickly between bacterial species and environments thanks to mobile genetic parts that carry multiple resistance genes.

Antimicrobial resistance is caused by a lot of different genetic and biological processes that often work together. Microorganisms' ability to change and survive antimicrobial treatment makes it even more important to be careful when using antibiotics, keep a close eye on things, and keep researching and developing new ways to treat illnesses.

Global Burden and Clinical Impact of Antimicrobial Resistance

One of the biggest problems in the world's health is antimicrobial resistance (AMR), which threatens modern medicine, food stability, and public health infrastructure. AMR is increasing illness, death, and healthcare costs around the world, according to the WHO, the CDC, and other global leaders. The GRAM Report 2022 found that AMR killed 1.27 million people around the world in 2019 and will kill another 5 million by 2022. Most of these deaths happened in low- and middle-income countries (LMICs) in Africa and South Asia.

1 High-Priority Resistant Pathogens

The clinical environment is increasingly dominated by drug-resistant Gram-negative bacteria. Who is priority pathogens contain major dangers like:

- Carbapenem-resistant Acinetobacter baumannii
- Carbapenem-resistant Pseudomonas aeruginosa
- ESBL-producing, carbapenem-resistant enterobacteriaceae
- Staphylococcus aureus (MRSA)
- Multidrug-resistant Mycobacterium tuberculosisThe “ESKAPE” pathogens—Enterococcus, Staphylococcus, Klebsiella, Acinetobacter, Pseudomonas, and Enterobacter—are renowned for hospital-acquired infections and drug resistance.

2 Clinical Outcomes and Implications

Because of AMR, doctors have to use dangerous or last-resort drugs like colistin or linezolid, which may not work well or have bad side effects. This makes you less likely to get infections:

- **Increased mortality and morbidity**
- **Longer hospital stays** and higher rates of ICU admissions
- **Greater risk of complications**, especially in immunocompromised or surgical patients
- **Elevated healthcare costs** due to prolonged therapy, diagnostics, and isolation measures
- **Therapeutic failure** in common infections like UTIs, sepsis, pneumonia, and surgical site infections

3 Impact on Medical Advancements

AMR could overturn decades of progress in medicine. Infections that are resistant raise the chance of organ transplants, chemotherapy, dialysis, and major surgeries. Without medicines, it is almost impossible to treat infections in these situations.

4 Economic and Societal Burden

The World Bank says that AMR could lower the world's GDP by 3.8% by 2050 and push 28 million people into extreme poverty, mostly in places that do not have good health care services. The economic burden is made heavier by indirect costs like lost output and long-term impairment.

CONCLUSION

Antimicrobial resistance (AMR) poses a danger to clinical medicine, infectious disease management, and national and international health initiatives. The presence of multidrug-resistant organisms in healthcare and community settings has resulted in the ineffectiveness of numerous common medicines, as well as an increase non patient morbidity, mortality, and overall healthcare costs across the world. Antimicrobial resistance poses a threat not just to individual illnesses but also to organ transplants, cancer chemotherapy, and major surgeries, all of which require effective antibiotics for infection control. There is a complex combination of factors that leads to antimicrobial resistance (AMR). These factors include improper use of antibiotics in human and veterinary medicine, antibiotic abuse and misuse, inadequate infection management, diagnostic limitations, and regulatory enforcement. It is imperative that those working in healthcare, research, legislative bodies, pharmaceutical corporations, and the general public collaborate in order to find solutions to these issues. the molecular underpinnings of antimicrobial resistance, the global burden of infections that are resistant, and the significance of taking action. Quick diagnostics, antimicrobial stewardship programs, bacteriophage therapy, CRISPR-based interventions, and novel antibiotics were some of the promising clinical and technological options that were investigated in this study. The goal was to reverse the trends that were already in place. To address antimicrobial resistance (AMR), a public health hazard, there is a need for global attention and commitment. In order to preserve the effectiveness of the antimicrobials that are currently available and to guarantee that future generations will have access to effective therapies, it is necessary to increase stewardship activities, research and innovation, rational antibiotic usage, and surveillance systems. In the absence of concerted action, the world runs the risk of entering a post-antibiotic era in which even the most basic infections could be fatal.

Bibliography

1. Aijaz, Moh, Mumtaz Ahmad, Mohamamd Anas Ansari, and Shmmon Ahmad. 2023. "Antimicrobial Resistance in a Globalized World : Current Challenges and Future Antimicrobial Resistance in a Globalized World : Current Challenges and Future Perspectives." (October).
2. Article, Review. 2017. "Global Health, Epidemiology and Genomics." doi: 10.1017/gheg.2017.4.
3. Branda, Francesco. 2024. "Implications of Artificial Intelligence in Addressing Antimicrobial Resistance : Innovations , Global Challenges , and Healthcare ' s Future."
4. Coque, Teresa M., Rafael Cant, Ana Elena P, Miguel D. Fern, and Fernando Baquero. 2023. "Antimicrobial Resistance in the Global Health Network : Known Unknowns and Challenges for Efficient Responses in the 21st Century."
5. Ferri, Maurizio, Elena Ranucci, Paola Romagnoli, and Valerio Giaccone. 2016. "Antimicrobial Resistance : A Global Emerging Threat to Public Health Systems Antimicrobial Resistance : A Global Emerging Threat to Public Health Systems." (May). doi: 10.1080/10408398.2015.1077192.
6. Hassall, Jack, Carmen Coxon, Vishal C. Patel, Simon D. Goldenberg, and Chrysi Sergaki. 2024. "Limitations of Current Techniques in Clinical Antimicrobial Resistance Diagnosis : Examples and Future Prospects." *Npj Antimicrobials & Resistance* 1–8. doi: 10.1038/s44259-024-00033-8.
7. Jindal, Brig A. K. 2014. "ScienceDirect Antimicrobial Resistance : A Public Health Challenge." 1:5–8. doi: 10.1016/j.mjafi.2014.04.011.
8. Kolawole, Tolulope Olagoke, Ashiata Yetunde Mustapha, Akachukwu Obianuju Mbata, and Busayo Olamide Tomoh. 2025. "Innovative Strategies for Reducing Antimicrobial Resistance : A Review of Global Policy and Practice Innovative Strategies for Reducing Antimicrobial Resistance : A Review of Global Policy and Practice Received : 16-12-2022 Accepted : 14-01-2023 Page No : 25-38." (January). doi: 10.54660/.IJFMR.2025.6.1.80-93.
9. Oliveira, Manuela, Wilson Antunes, Salete Mota, and Á. Madureira-carvalho. 2024. "An Overview of the Recent Advances in Antimicrobial Resistance." 1–50.
10. Papastergiou, Vasilios, Sotirios D. Georgopoulos, and Stylianos Karatapanis. 2014. "Treatment of Helicobacter Pylori Infection : Meeting the Challenge of Antimicrobial Resistance." 20(29):9898–9911. doi: 10.3748/wjg.v20.i29.9898.
11. Ponzo, Elena, Silvia De Gaetano, Angelina Midiri, Giuseppe Mancuso, Presti Giovanna, and Danna Giuliana. 2024. "The Antimicrobial Resistance Pandemic Is Here : Implementation Challenges and the Need for the One Health Approach." 297–316.
12. Roca, I., M. Akova, F. Baquero, J. Carlet, M. Cavaleri, S. Coenen, J. Cohen, D. Findlay, I. Gyssens, and O. E. Heure. n.d. "The Global Threat of Antimicrobial Resistance : Science for Intervention." *New Microbes and New Infections* 6(April 2015):22–29. doi: 10.1016/j.nmni.2015.02.007.
13. Spellberg, Brad, John Bartlett, Rich Wunderink, and David N. Gilbert. 2015. "Novel Approaches Are Needed to Develop Tomorrow ' s Antibacterial Therapies." 191:135–40. doi: 10.1164/rccm.201410-1894OE.