2021 YUM! ANTIMICROBIAL RESISTANCE REPORT

Research conducted by PreScouter

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PROLOGUE

In early 2021, as part of Yum! Brands' continued antimicrobial resistance (AMR) journey, the company's sustainability team had an ongoing dialogue with a shareholder who filed a proposal regarding the issue of AMR. As a result of our discussions, it was agreed that Yum! would produce a report on AMR that provides or addresses the following:

- Greater context on AMR, the systemwide costs of AMR and strategy for quantifying external AMR costs
- Stakeholders who absorb these costs
- An optimal global scenario to eliminate or internalize AMR costs
- Competitive concerns
- How Yum! policies and procedures could influence the global scenario

Prior to working on the report, we established key principles to guide its production including that the report must remain grounded in evidence-based, sound science and balance the complex nature and increased pressure in the AMR space.

We commissioned a third-party organization to conduct the research, which included a review of existing data and literature and interviews with subject matter experts (SMEs). Additionally, a leading AMR expert worked closely with the third-party organization and our team to help ensure the accuracy and quality of the content included in the report, as well as to provide oversight throughout the report's production.

The content contained in the report is intended to be a snapshot of the current state of research, outlined above and isn't a holistic review of all AMR data and literature. We acknowledge that AMR is a complex and multifaceted issue, and this report is only one output with a limited scope.

We believe that by continuing to better understand the broader AMR landscape and existing research that Yum! can make more progress when it comes to programs and policies to positively impact the global AMR scenario. In addition, we are committed to being a good steward of the animals raised for food throughout our supply chain and that includes playing a positive role in the responsible and judicious use of antimicrobials and decreasing AMR.

Across the Yum! system, we take a thoughtful, comprehensive health management approach to our AMR programs, which may necessitate the use of antibiotics for animal health. We share concerns regarding the rising threat of AMR and support One Health, a holistic and multi-sectoral, long-term effort to combat AMR by the United Nations World Health Organization (WHO), the Food and Agriculture Organization (FAO), the World Organisation for Animal Health (OIE) and other key stakeholders.

EXECUTIVE SUMMARY

This report is intended to evaluate the global costs associated with AMR and better understand the high-level drivers and mitigation strategies, which impact cost. In this report, we disentangle the elements and identify the relative contribution of individual factors to global AMR costs at large. The investigation, conducted by PreScouter, combined data from existing research articles, policy white papers and market research reports with research conducted through interviews with SMEs. The research portion of this investigation included a panel of 12 experts on global health, epidemiology, infection control, medical microbiology and health economics.

As of 2021, it is thought that the global cost of AMR, including direct and indirect costs, is significant and that these costs are largely driven by the increase in infections caused by antibiotic resistant bacterial species; with infections from A. baumannii, E. coli and S. pneumoniae driving more than 54% of AMR costs by 2027. In addition, AMR contributes to costs worldwide through an increased strain on the medical system.

While quantifiable risks and costs are well documented, AMR attribution is challenging. One major driver is the misuse of medically important human antibiotics. At its core, three separate but interrelated issues involving the use of medically important human antibiotics — excess, access and governance — influence AMR. Excess includes easy to obtain and relatively inexpensive antibiotics, often leading to overuse and misuse. Access problems include no access, delayed access and access to mostly counterfeit antibiotics. Poor access can result in an increased misuse of higher group antibiotics as well as unnecessary deaths. Inadequate governance, with limited or no immediate tangible consequences, fosters overuse and misuse. While research indicates that a major driver of AMR is medical misuse of antibiotics, the following are identified as key drivers in each economic category:

- Misuse of antibiotics in the medical, agricultural and food sectors are seen as playing a role in high-income countries.
- Middle-income countries have poorly regulated agriculture as one of their largest drivers of AMR.
- Sanitation and economics in low-income countries are major issues that contribute to poor access and misuse.

The problem of AMR cannot be solved with quick-fix solutions. Responsible antibiotic prescription and more specific use of antimicrobials in humans **may be the highest impact strategy for reducing AMR's impact moving forward**. In agriculture, effective strategies have included removal of preventative antibiotics from the value chain, improved monitoring of suppliers and targeted removal of medically relevant antibiotics from operations. Enhancing husbandry practices, judicial use of antimicrobials for animals, AMR monitoring and improvement of animal sanitation are seen as critical AMR reduction strategies. Key enablers for these strategies are continued research and development efforts on the data collection and diagnostics side, as well as educational programs and awareness initiatives at a larger scale.

Lastly, the outbreak of COVID-19 (the coronavirus SARS CoV-2) has put the global health care sector under extreme pressure. Experts state that the pandemic will surely have its repercussions on AMR costs and that it will take some time to evaluate whether this has had a positive or negative impact on AMR that will likely vary from country to country.

KEY FINDINGS

- **AMR is increasing and research indicates that direct costs imposed on the healthcare system worldwide are currently significant.** These costs are largely driven by the increase in infections caused by antibiotic resistant bacterial species. It is difficult to assign particular numeric values to the costs of AMR given the low reliability of the data acquired worldwide.
- **Mitigation strategies that have decreased AMR and costs have mostly been deployed on a national level.** In the U.S., as a result of a U.S. Federal Drug Administration (FDA) 2017 mandate on restricted antibiotic use in livestock production implemented by the Veterinary Feed Directive (VFD), the consumption of antibiotics by livestock and occurrence of AMR by bacteria that inhabit both livestock and humans appear to have decreased (Dillon 2020). Other successful national mitigation strategies include those in the Netherlands and Sweden. According to our interviews with SMEs, the effects of strategies deployed on a national level can transcend borders. This amplification of effect size is also true for companies.
- **Existing AMR efforts in the food industry are largely based on a compliance approach in countries of operation.** Exceptions to this trend are increasing, especially among larger global firms, and companies are removing antibiotics from their entire supply chain.
- **Government strategies are far-reaching but might take between five to 10 years to implement.** In contrast, private companies may have the ability to move faster due to more nimble operations, but it can be challenging for them to impact the broader industry. Partnerships between the private and public sectors work best to implement change at scale.
- **The lack of reliable economic data associated with AMR caused by antibiotic use in agriculture limits the ability to quantify the cost of AMR in the agricultural space.** Our research suggests that the agricultural cost of AMR is meaningful in trade disruption alone, with outbreaks of resistant bacteria causing incidents that can increase these costs directly, or indirectly via culling, penalties, etc.
- **The number and intensity of public and private antibiotic stewardship initiatives has increased over the last few years.** Common partnerships for mitigation strategies occur between the public and private sectors. A key example is the AMR Challenge, a year-long global challenge organized by the Centers for Disease Control and Prevention (CDC) in 2018. This resulted in 345 commitments from public and private institutions, including Yum!.
- **The outbreak of COVID-19 has put the global healthcare sector under extreme pressure.** The increased use of antibiotics for COVID-19 secondary infections may lead to an acceleration of AMR trends moving forward (Center for Food Safety 2021).

BACKGROUND

AMR is the capacity of a microbe to adapt and survive under the inhibitory activity of antimicrobial compounds (Verraes et al. 2013). Once AMR is achieved by bacteria, antimicrobials that were previously effective at treating patients with this microbe no longer work. These acquired resistance events across bacterial strains collectively contribute to AMR as a global problem. The higher the frequency of these events, the more difficult the treatment for infectious diseases becomes and the higher the incidence of severe outcomes. The resulting increased mortality, overloading of healthcare systems and disruption of economic activity/trade are the major drivers of AMR-related costs.

The large and growing volume of antibiotic use in the last decades in healthcare and agriculture, coupled with the discovery of relatively few new antibiotics, has led to AMR as a growing global health and economic threat (CDC 2019). AMR is recognized as a global health issue in the eyes of many policy makers, scientists and civil society organizations. AMR is reported among the 21st century's main threats, and the United Nations has recognized AMR as a "long-term threat to human health [and] sustainable food production and development" (UN, 2016). Further, the WHO, Food and Agricultural Organization (FAO) and the World Organization for Animal Health (OIE) have developed a One Health approach in the face of this issue (FAO, OIE, WHO 2010, WHO 2017a). In addition to the economic impact of AMR, the societal impacts driven by mortality, increased hospitalization rates and trade disruption could be even more costly (Innes, G, 2019, World Bank 2017).

According to the WHO, coordinated global efforts to minimize the impact of AMR are necessary (Queenan et al. 2016). Although responsible consumption of antibiotics alone might not be sufficient to tackle AMR, an integrated strategy around antimicrobial stewardship, AMR surveillance and judicial use of antimicrobials may help the human population to attenuate AMR worldwide (Aliabadi et al. 2021). While there have been encouraging signs in government policy and private action, unified multilateral action has yet to move from proposal to concrete and enforceable policy.

> "The threat of AMR to the global economy was only recognized in the last few years; consequently, the effects of mitigation strategies are yet to be advanced."
> *- Head of R&D Medical Microbiology and Infection Control in the U.K.*

AMR Drivers	Mitigation Steps
Antimicrobial Use (misuse/overuse)	Improved Use of Antimicrobials
Antibiotics for Growth Promotion	Judicious Use of Antimicrobials
Suboptimal Diagnostics	Reliable Data Monitoring
Poor Sanitation & Water Quality	Improved Sanitation Measures
Overcrowded Populations	Education & Awareness

Yum! Efforts
Compliance with Local Regulators
Responsible Use of Antimicrobials
Effective Animal Husbandry Practices
Suppliers Audition for Quality Standards

DRIVERS OF AMR

Antibiotic use is crucial to combat bacterial infection. Widespread medical use and misuse of antimicrobials is a mainspring associated with increased AMR (Singer et al. 2016). Both overuse and misuse of antibiotics in hospitals and care settings, together with over-the-counter access of antibiotics, have been well-studied. Several papers report the major impact of these drivers on the development and spread of resistant microbes, particularly within high-income countries (Vikesland et al. 2019). Agriculture and animal husbandry practices including overuse of antibiotics for disease prevention or growth promotion, overcrowding, and insufficient sanitation may also have a significant, though lesser, impact on the rise of AMR.

The four main objectives in agricultural antibiotic use are treatment, control, prevention and production. In this report, we consider treatment to be administering antibiotics to individuals or groups that are showing signs of illness. Control, sometimes called metaphylaxis, is treating a group or subgroup that has been exposed to a person or animal showing clinical illness to prevent further spread. Prevention, or prophylaxis, is giving antibiotics to a group where there are no clinical signs of disease, but there are risk factors or high-risk populations where failure to give antibiotics may result in future disease. Production uses include giving antibiotics at low levels to increase feed efficiency or promote growth. In U.S. food animal production, antibiotics are used for treatment, control, prevention and production. However, production uses of human class antibiotics for use in animals are no longer allowed in the U.S. Antibiotics are overwhelmingly used to treat clinical illness in human medicine and are rarely employed for disease control in humans. An example is administering antibiotics for a short time to a family or social group to prevent further spread of bacterial meningitis (Peltola 1999). Even more rarely, antibiotics are used in human medicine such as is recommended to prevent malaria that has not yet occurred but has a significant probability of causing harm if a person is infected (CDC 2018).

The use of antimicrobials for food production in animal husbandry is purported to have impacted the spread of AMR over the last decade, but the magnitude of this impact remains challenging to define (O'Neill 2016). Regarding antibiotic use, agriculture and livestock settings account for approximately two-thirds of global antibiotics. Antibiotics are mostly used for treating a pathogen or as a prophylactic measure to prevent infections in agriculture (Nhung et al. 2017). Continual application of antimicrobials to the water or the food that the animals feed on at full or subtherapeutic doses can prevent new occurrences of disease or the spread of infections, but it can also increase the likelihood of developing resistant microbes (Wall et al. 2016). And, depending on the drug, about 30% to 90% of the antibiotics administered to animals in the feed or water are released back into the environment as urine or manure. If not well treated, the discharge of animal waste can contaminate bodies of water with antibiotics, creating yet another potential source for the development of AMR (Singer et al. 2016). However, the overall contribution of animal antimicrobial treatments to AMR has yet to be fully elucidated due to the complex array of factors that can contribute to AMR in this setting (Wu 2017).

Although the use of antibiotics is primarily correlated with the surge of resistant microbes, other factors may also contribute to the global development of AMR (Wall et al. 2016). Significant additional drivers include poor sanitation standards, untreated wastewater and high human population densities. These factors lead to increased contact with contaminated environments and, therefore, a higher prevalence of infectious diseases (Holmes et al. 2016, Vikesland et al. 2019). Other factors causing an escalation of AMR include ineffective and/or underutilized vaccination, which could reduce infection prevalence and transmission, and inefficient and/or insufficient diagnostic procedures that could otherwise prevent antibiotics overuse and misuse (Holmes et al. 2016).

Importantly, many of the above factors point to alternative practices that can decrease the need for excessive antibiotic use in animal husbandry. Improved sanitation and lower population density in animal agriculture have been shown to decrease the rate of infection and the need for antibiotics in agricultural practice (Tiseo et al. 2020, Schoenmakers 2020). Additionally, utilizing improved surveillance systems on an agricultural scale may decrease the incidence of AMR generation; while a scalable solution for agriculture has yet to be developed, groups such as Nesta are funding research to develop these tools (Nicholson et al. 2020).

The socioeconomic risk factors involved in the increased prevalence and surge of resistant microbes create a higher burden for low- and middle-income countries, compared to high-income countries. For low-income countries, poverty and poor sanitation conditions are considered the main drivers of AMR. For middle-income countries, the relatively unregulated use of antibiotics in humans and agriculture are the major AMR-related threats (Van Boeckel et al. 2019). It is notable that there is a publication bias that may be impacting these results: A greater number of AMR studies have been conducted within high-income countries, leading up to an unbalanced knowledge about the impacts of AMR in lower-income settings (Vikesland et al. 2019).

COVID-19 AS A DRIVER OF AMR

Additionally, COVID-19 has served as a driver of AMR in human health. General hygienic measures for the containment of the COVID-19 pandemic have led to an overall reduced number of bacterial infections of people in most European countries. On the other hand, some healthcare systems have shown an increase in antibiotic prescriptions to combat COVID-19 secondary infections at rates significantly higher (94%-100%) than the actual prevalence of COVID-19 secondary infections (10%-15%) (Rossato et al. 2020). There is a fear that the increased use of antibiotics for prevention during the pandemic may lead to a long-term increase in AMR trends (Center for Food Safety 2021).

IMPACT OF AMR ON SOCIETY

POTENTIAL GLOBAL ECONOMIC IMPACT

A low-AMR scenario could reduce the global GDP by 1.1% by 2050, which represents a direct cost of around $1 trillion USD per year (Figure 1). Under a high-AMR scenario, the World Bank estimates a global GDP shrinkage of 3.8%, with direct costs reaching over $3 trillion USD, annually (World Bank 2017). However, even high-AMR scenarios may reflect an underestimation of the true costs of AMR because of the challenges in calculating second order effects related to trade and other broad economic activity (Smith & Coast 2013). Given the low reliability of the data acquired worldwide, it remains difficult to quantify the appropriate range of the potential economic impact presented by AMR with any certainty.

> "The economic consequences of AMR are yet very poorly understood. This is in part due to a lack of reliable data, but also because the currently employed methods still focus on costs at the individual patient level, rather than having a holistic view on the matter."
> *- Professor of Animal Infection Prevention in Sweden*

Low-income countries are the most strongly impacted by AMR due to the high prevalence and impact of infectious diseases (e.g., malaria or tuberculosis). Taking both public and private healthcare expenditures into account, the costs of AMR-related disease burden are expected to rise by 25% in low-income countries by 2027. In contrast, these costs are expected to increase by only 15% and 6% in medium- and high-income countries, respectively by 2027 (World Bank, 2017).

Potential Global Impact of AMR on GDP

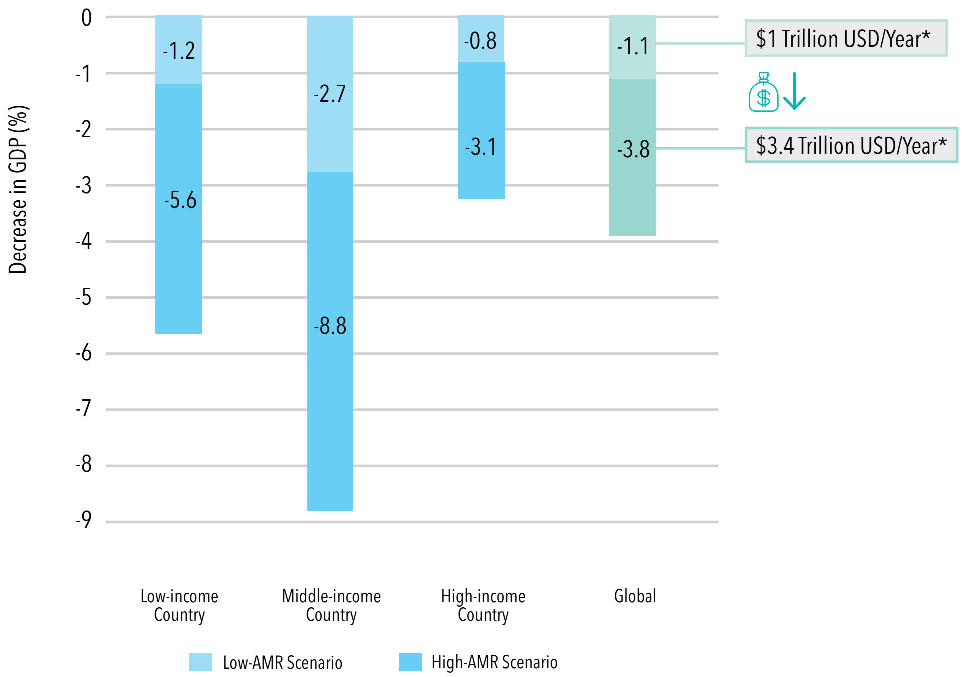

Figure 1. *Global GDP reduction projections under low- and high-AMR scenarios. (Data from the World Bank 2017)*

According to our research, the current direct costs of AMR are approximately $10 billion USD worldwide. Notably, this is within the range of cost estimates made by other organizations, although it does not cover second-order impacts of AMR such as trade disruption. With a global compound annual growth rate (CAGR) of 4.3%, the global direct cost of AMR is expected to reach $13.8 billion USD by 2027. **Almost half of the costs used to calculate this value come from hospitals (46%), followed by research institutes (24%) and clinics (20%).**

Potential Global Costs of AMR

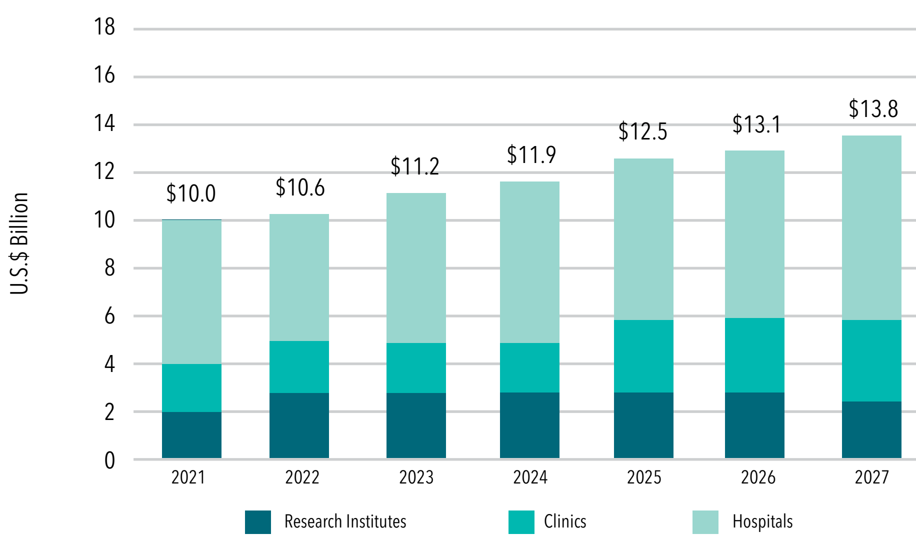

Figure 2. *Global direct costs imposed by AMR in 2021 and estimates for the next six years (PreScouter Primary Research).*

North America and Europe, together, constitute over half (51.3%) of the global direct costs imposed by AMR (Figure 3). North America, Europe and Asia-Pacific are the primary drivers of global AMR direct costs, with a combined value of $7.4 billion USD in 2021 and estimated at $10.2 billion USD for 2027 (73% and 74% of the total value, respectively).

Potential Market Value of AMR, by Continent

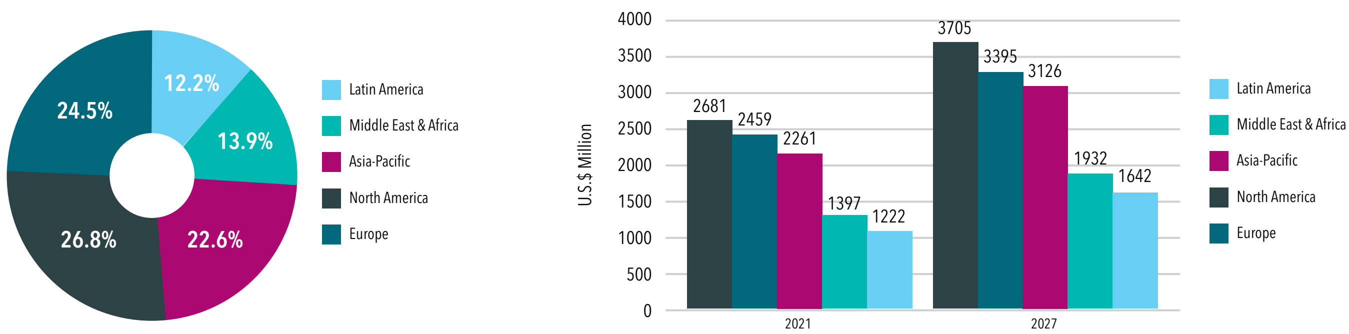

Figure 3. *Direct AMR market costs per continent. Left: AMR as a percentage of total global costs, per continent, reported for 2021. Right: Direct AMR costs, per continent, reported for 2021 and estimates for the next six years (PreScouter Primary Research).*

Research into the direct costs of AMR were further broken down by bacterial strain. At a global level, human infections caused by drug-resistant strains of Acinetobacter baumannii have the highest economic cost to society (Figure 4). This microbe is primarily associated with infections on the skin of immunocompromised hospital patients and currently exhibits considerable resistance to the majority of the available first-line antibiotics (Howard et al. 2012). Resistant strains of A. baumannii are responsible for a total cost of $2.5 billion USD in 2021 and an estimated $3.5 billion USD by 2027, followed by Escherichia coli and Klebsiella pneumoniae, accounting together for $1.8 billion USD in 2021 and estimated at $2.4 billion USD by 2027. A current challenge with these kinds of cost models is the lack of reliable data from regions outside of North America and Europe. This may bias the cost data and underestimate the impact of major infection such as M. tuberculosis, the biggest bacterial killer worldwide, with an annual mortality rate of about 1.2 million (WHO, 2019).

Potential Global Costs of AMR, by Pathogen

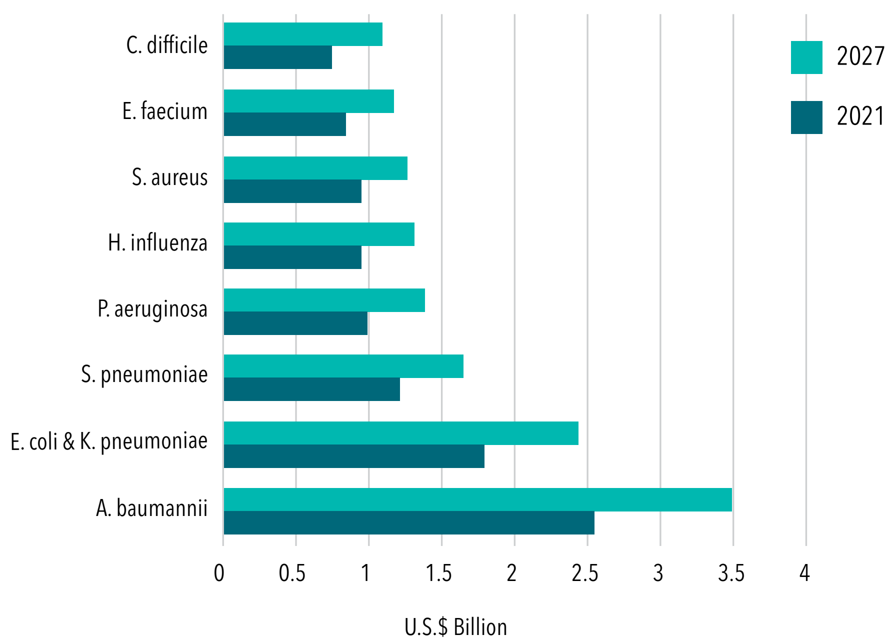

Figure 4. *Potential AMR healthcare costs of selected bacteria excluding TB. (PreScouter Primary Research)*

Besides direct costs (e.g., hospital admission and treatment costs), AMR is also responsible for an increasing number of indirect economic losses due to increased illness, morbidity and disabilities. These reflect on lower productivity rates and are referred to as the indirect costs of AMR (World Bank, 2017). However, these indirect costs are necessarily more difficult to estimate.

COSTS OF AMR IN THE U.S.

According to the CDC, almost 3 million people in the United States become ill with antibiotic-resistant diseases every year, resulting in more than 35,000 annual deaths (CDC, 2019). Compiling direct and indirect impact, the CDC estimates that the costs imposed by AMR in the U.S. were $5.6 billion USD in 2019. Regarding particular pathogens, the CDC estimates the following costs:

- $281 million for carbapenem-resistant Acinetobacter
- $1 billion for Clostridioides difficile
- $130 million for carbapenem-resistant Enterobacteriaceae
- $133.4 million for drug resistant Neisseria gonorrhoeae
- $1.2 billion for extended spectrum beta lactamase producing Enterobacteriaceae
- $539 million for vancomycin-resistant Enterococci
- $767 million for multidrug-resistant Pseudomonas aeruginosa
- $1.7 billion for methicillin-resistant Staphylococcus aureus (MRSA)

While these costs serve as estimates including both direct and indirect costs, **the CDC also indicates that it can be very difficult to fully quantify the economic impact of AMR. Importantly, mitigation efforts in the US have improved the outlook since the CDC's 2013 report.** Particularly, they note that **dedicated prevention and control efforts have helped reduce the number of infections and deaths caused by antibiotic resistant bacteria in the U.S. (CDC 2019).**

IMPACT OF AMR IN AGRICULTURE

AMR in humans and animals — particularly for food animals — is intrinsically connected. Bacteria which obtain resistance during food production and livestock management can transfer directly to humans, and waste antibiotics can induce AMR outside of controlled agriculture settings. AMR reduces the productivity of agricultural and livestock industries through, for instance, trade disruption, animal death and the need to destroy contaminated stock. This, in turn, increases the cost of meat and dairy products and broadly disrupts the agriculture sector (World Bank 2017). Given these factors, the industry is interested in balancing the challenges of maintaining healthy livestock and reducing the incidence of AMR.

Reports have recently shown a substantial reduction in the use of antimicrobials within the poultry industry in the U.S.; however, the same does not hold true for the beef and pork sectors, in which the use of antimicrobials may have been slightly rising since 2018 (Center for Food Safety 2021). There is a lack of consensus by SMEs of the economic or health costs of AMR in agriculture or of its costs in human populations. Robust models to estimate AMR costs due to antibiotic use and animal husbandry practices in agriculture are still nascent (Innes et al. 2019).

Lack of sufficient reporting may make it difficult to measure costs, but the array of reporting networks in mid- to high-income countries allow us to accurately measure the volume of antibiotic use. It is estimated that global consumption of veterinary antimicrobials was 93,309 tonnes in 2017, and this is projected to grow to 104,079 tonnes by 2030 (Tiseo et al. 2020). Notably, a significant majority of this projected consumption comes from China, accounting for 45%, with Brazil accounting for 7.9% and the U.S. accounting for 7%. A great deal of China's agricultural antibiotic use is purported to be driven by a significant increase in the demand for pork, which has necessitated higher crowding of animals and thus higher antibiotic consumption (Yang et al. 2019).

While there is no direct correlative line between antimicrobial consumption in agriculture and AMR broadly, a number of studies have been conducted on the direct costs AMR can impose on agriculture. These direct costs include operational agriculture costs such as the need to cull sick animals, costs that come from direct transmission of foodborne illnesses, destroying contaminated food and disruptions to trade. As an example, in 2011, an outbreak due to drug resistant E. coli in fenugreek sprouts led to 53 deaths, $1.3 billion USD losses for German farmers and industries, and up to 236 million emergency aid payments to European Union (EU) states (Criscuolo, N. G. 2021). More broadly, the World Bank has reported that AMR could result in a decline in total food production caused by livestock deaths and international trade disruption of between 2.6% to 7.5% (FAIRR 2021).

MITIGATION STRATEGIES

PUBLIC SECTOR

Governments generally drive AMR mitigation strategies aimed to reduce the global emergence of resistant pathogens. From a governmental perspective, the development of AMR mitigation strategies is most effective when implementing combined regulatory legislation, policies, programs and research within different sectors (WHO 2017a, Council of Canadian Academies 2019). These public sector actions set a supporting baseline for further private sector action by discouraging the undercutting of competitors through employing practices that can drive AMR.

> "The design of AMR strategies by the One Health lens have increased our chances to successfully mitigate AMR."
> *- Assistant Professor in Epidemiology in Switzerland*

To respond to the growing AMR crisis, the May 2015 World Health Assembly (WHO 2016) adopted a global action plan on AMR, which outlines five objectives:

1. To improve awareness and understanding of antimicrobial resistance through effective communication, education and training
2. To strengthen the knowledge and evidence base through surveillance and research
3. To reduce the incidence of infection through effective sanitation, hygiene and infection prevention measures
4. To optimize the use of antimicrobial medicines in human and animal health
5. To develop the economic case for sustainable investment that takes account of the needs of all countries and to increase investment in new medicines, diagnostic tools, vaccines and other interventions

Countries have adopted a range of AMR mitigation strategies. Countries that have implemented notably comprehensive strategies over the last decade include the Netherlands and Sweden (Figure 5). Both countries implemented a combination approach of infection prevention, increased AMR awareness, a comprehensive regulatory framework for human and veterinary prescription, and the availability of reliable databases on disease incidence. These efforts were coordinated between governments, academia, farmers and the private sector. As a result, over five years, government antibiotic stewardship in the Netherlands reduced antibiotic use in animals by 56% (Speksnijder et al. 2014). Sweden's mitigation strategies, by comparison, have reduced the use of antibiotics by 13% in 2020 compared to 2019 (Swedres-Svarm 2020).

Key AMR Mitigation Milestones

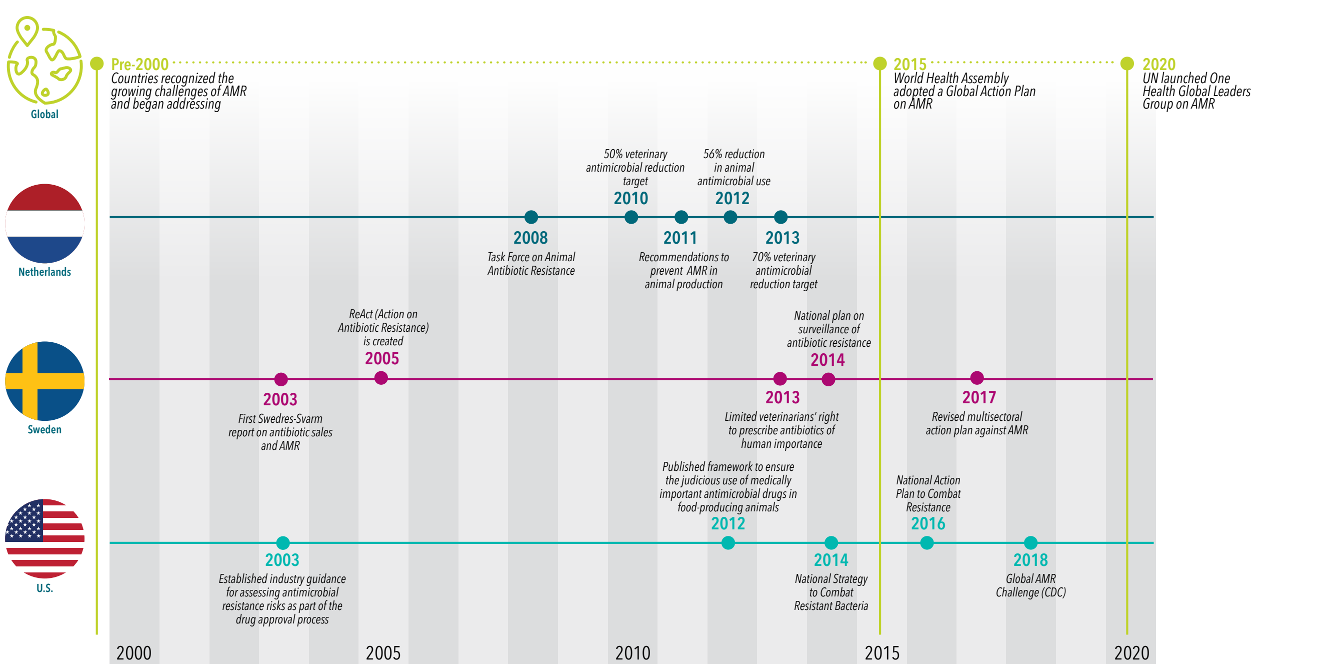

Figure 5. *Overview of some of the AMR mitigation plans, including regulation and reporting, implemented by the Netherlands, Sweden and the U.S. governments in the last two decades. This chart is not comprehensive and only a snapshot of some of the key milestones that have occurred and countries that have taken action. (Data from Speksnijder et al. 2014, Eriksen et al. 2021, CDC 2019, CSIS 2020, FDA 2021 and WHO 2020)*

The U.S. is also taking steps towards curbing the excessive use of antimicrobials to combat AMR. For example, the FDA Center for Veterinary Medicine and animal drug manufacturers completed the transition of all medically important antimicrobial drugs used in animal feed and drinking water from over-the-counter (OTC) medications to require veterinary oversight, including revising the Veterinary Feed Directive (VFD) (FDA 2017). This requires the use of these drugs to be authorized by a licensed veterinarian, thus curbing their use. This regulation does not necessarily mandate a reduction in antibiotics, so long as a licensed veterinarian is authorizing the use of antibiotics. **The most recent data from the FDA from 2019 showed a drop in sales and distribution of "medically significant antimicrobials licensed for use in food-producing animals,"** according to figures issued in 2020 (FDA 2019):

Table 1. Drop in sales and distribution of medically significant antimicrobials licensed for use in food producing animals

Species	2016 Estimated Annual Totals (kg)3	2017 Estimated Annual Totals (kg)3	2018 Estimated Annual Totals (kg)3	2019 Estimated Annual Totals (kg)3	% Change 2016 - 2019	% Change 2018 - 2019
Cattle	3,605,543	2,333,839	2,517,386	2,529,281	-30%	<1%
Swine	3,133,262	2,022,932	2,374,277	2,582,399	-18%	9%
Chicken	508,800	268,047	221,774	192,964	-62%	-13%
Turkey	756,620	670,831	671,108	644,921	-15%	-4%
*Other**	352,114	263,564	247,753	239,694	-32%	-3%
Total	**8,356,340**	**5,559,212**	**6,032,298**	**6,189,260**	**-26%**	**3%**

**The Other category includes estimates of product sales intended for use in (1) species listed on the approved label other than cattle, swine, chickens, and turkeys, including nonfood-producing animal species (e.g., dogs and horses) and minor food-producing species (e.g., fish); (2) other species not listed on the approved label; and (3) unknown uses.*

To develop a deeper understanding of critical mitigation strategies for AMR, we conducted interviews with a panel of experts in the field. Some of the key AMR mitigation strategies they identified were reducing use of antimicrobials in agriculture and healthcare, engaging in infection prevention, making data available, innovation in diagnostics and therapeutics and sanitation. Importantly, when asked to score the importance of these initiatives, our expert panel agreed with very low variance that the strategies were of almost equal importance. This highlights the broad perception in the space that an "all of the above" approach, of which reducing antibiotic use in animal husbandry is a part, is required for addressing AMR (Figure 6). There has recently been a significant increase in the utilization of monitoring and data tracking platforms (e.g., Criscuolo et al. 2021, Freifeld et al. 2008) that provide essential information to tackle resistance hotspots, particularly in Europe (ECDC, EFSA & EMA 2021, UK-VARSS 2019, NethMap 2021). The regions which use these technologies are able to respond to outbreaks of AMR sooner, reducing their health and economic impacts.

Importance of Key AMR Mitigation Strategies

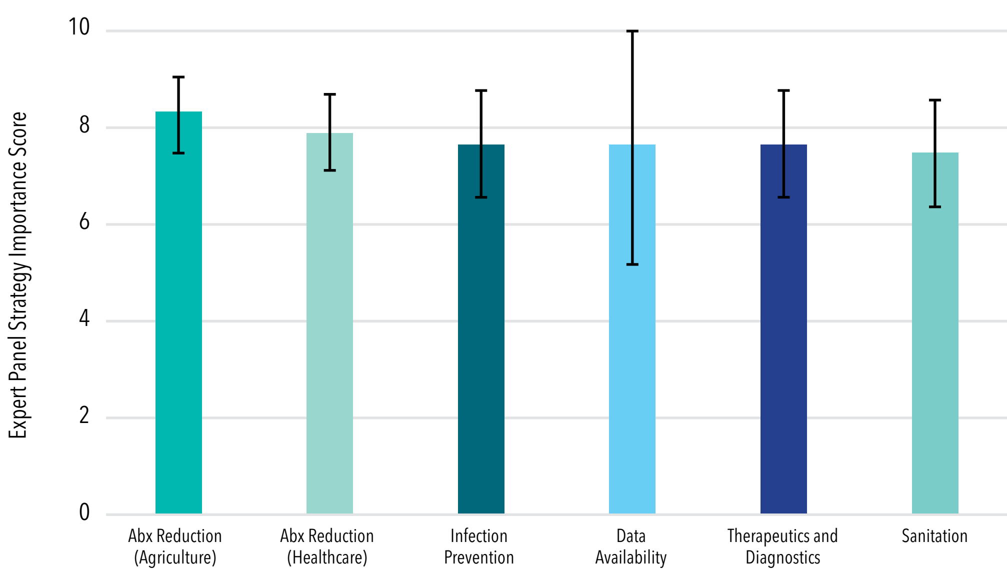

Figure 6. *Expert panel evaluation of the relative importance of the main AMR mitigation steps according to the One Health Approach with a 1 indicating low importance and 10 indicating high importance. Importance scoring by our expert panel reveals the relevant contribution of all mitigation steps (Expert Panel Interviews).*

Low-income countries tend to have a different approach to addressing AMR reduction. Given the reduced financial resources, low-income countries pursuing AMR reduction primarily center on less infrastructure intensive initiatives such as educational programs and awareness campaigns around the use of antibiotics in agriculture and the impact of AMR. Examples of low-income countries that have successfully implemented these strategies include Pakistan and Cambodia. Both of these countries have administered national action plans in line with the WHO recommendations (WHO 2017b, WHO 2019, Saleem et al. 2021).

> "Education is changing to make sure that prescriptions are made wisely and that patients know that antibiotics are not always necessary."
> *- Professor of Antimicrobial Stewardship in Scotland*

Limited infrastructure and programs are among the main challenges preventing AMR mitigation in low- and middle-income settings. In these countries, negligible funding, weak laboratory infrastructure, limited staff capacity and communication issues are considered barriers to effective surveillance of AMR (Iskandar et al. 2021).

Reducing AMR trends within the food system can be achieved through clear antibiotic stewardship (with solid legislation and regulations) by governments. Effective strategies will include both prevention and control of infectious diseases, consequently culminating in a reduced need for antibiotics.

> "Changing the message around antibiotics can combat the idea that farmers have that using fewer antibiotics will consequently reduce food production."
> *- Professor in Public Health in Singapore*

PRIVATE SECTOR

Examples of mitigation strategies employed at in the private sector include responsible use of antibiotics and enhanced hygienic procedures to prevent crossover and spread of AMR-associated microbes (e.g., less crowded and cleaner facilities, continuous AMR monitoring). Collectively, these measures have the potential for further reducing the clinical need for antibiotics (FAO 2021).

Effective AMR mitigation strategies require joint efforts between both the governments and the private sector. Ideally, consumers would participate as well to reinforce the companies' actions and motivations (Expert Panel Interviews).

Only a handful of private companies from the food sector provide information about their past, current and future strategies for AMR (FAIRR 2021). However, given the increasing focus on AMR, private companies have started to outline plans for judicial use of antibiotics on food items. For example, a commonly implemented strategy is to minimize antibiotics of importance to human health from meat chain suppliers. A typical example of antibiotic stewardship from private companies includes restriction of the use of critically important antibiotics, responsible routine use of antibiotics for prophylactic purposes and constant support for R&D opportunities for judicial consumption of antibiotics.

> "The private sector has the opportunity to work proactively with governments before mandatory regulations are implemented."
> *- Senior Research in Health Economics in the U.K.*

A proactive reduction of antibiotics in agriculture can be an effective strategy to mitigate AMR at a corporate level. Doing this will synergize with government efforts and decrease the spread of AMR and associated costs. Reducing the overall use of antibiotics in agriculture, in concert with government mitigation strategies could double the pace at which AMR reduces.

> "Better compliance with regulatory frameworks from the private sector shall strengthen the policies employed by governments and could decrease the time to combat AMR by half."
> *- Assistant Professor in Epidemiology in Switzerland*

YUM!'S EFFORTS & POLICIES

Yum! established its animal welfare program in 2002 and has evolved it since then, including publishing its Sustainable Animal Protein Principles in 2017. In 2020, Yum! implemented health management programs dedicated to track and monitor animal health and wellbeing (Yum! 2020). Although these may necessitate the use of antibiotics and antimicrobials to maintain or restore good animal health, Yum! shares concerns regarding the rising threat of AMR and is committed to sustaining an antimicrobial stewardship program throughout its global supply chain (Figure 7). Besides compliance with governmental regulations, the good antimicrobial stewardship implemented by Yum! includes:

a. Responsible, judicious use of antimicrobials to benefit human, animal and environmental health
b. Reducing, and eliminating where possible, the use of antimicrobials important to human medicine
c. Including effective animal husbandry practices and alternative interventions that reduce risks to animal health
d. Implementing solutions specific to and compliant with each country's regulations, taking local supply chains, breeds of animals and disease profiles into consideration
e. Surveillance and monitoring antimicrobial use by auditing suppliers to confirm compliance with Yum!'s safety and quality standards for food animals

Yum!'s Elements of Good Antimicrobial Stewardship

- Effective animal husbandry practices and alternate interventions that reduce risks to animal health.
- Responsible judicious use of antimicrobials
- Science-based solutions
- Solutions tailored by country and region
- Compliant with local government and regulations
- Surveillance and monitoring of antimicrobial usage

Figure 7. *The Yum! Brands' antimicrobial stewardship program.*

Yum! is part of the One Health endeavor which is a multi-sectoral, long-term effort to combat AMR by the WHO, FAO, OIE and other key stakeholders. In 2019, Yum! joined the CDC AMR Challenge, a global commitment to accelerate the fight against antimicrobial resistance. The AMR Challenge was an effort by the U.S. government to accelerate the fight against AMR.

Yum! subsidiaries KFC, Pizza Hut and Taco Bell in the U.S. have met public commitments to reduce antibiotics important to human medicine in their U.S. poultry supply chains and have made new commitments to drive further progress. Currently, all of Yum!'s U.S. meat and poultry suppliers follow U.S. FDA guidelines for antibiotic use in food animals.

Table 2. Yum! Commitments for Responsible Use of Antibiotics

Subsidiary	Commitments	Status
KFC U.S.	To remove antibiotics important to human medicine from its poultry supply	Complete
Pizza Hut U.S.	To remove antibiotics important to human medicine from its chicken toppings for pizza	Complete
Pizza Hut U.S.	To remove antibiotics important to human medicine from chickens used for wings by 2022	In progress
Taco Bell U.S.	To remove antibiotics important to human medicine for all chicken products	Complete
Taco Bell U.S. and Canada	• To reduce antibiotics important to human health by 25% in beef supply chain by 2025 • To give preference to beef suppliers that make measured reductions in their use of antibiotics • To participate in animal husbandry practices that promote antibiotic stewardship • To share progress on beef goal in 2022	In progress

In addition, Yum! is engaging with internal and external stakeholders, including the U.S. Roundtable for Sustainable Beef (USRSB) and the International Consortium for Antimicrobial Stewardship in Agriculture (ICASA). The U.S. Roundtable for Sustainable Beef is a multi-stakeholder initiative developed to advance, support and communicate continuous improvement in sustainability of the U.S. beef value chain. ICASA is collaborating across the supply chain to pioneer technologies and management practices that promote judicious antibiotics use and produce healthier livestock. Progress on this engagement will be shared in 2022.

Yum! also uses the USDA Process Verified Program (PVP), third party auditing system. This verification process ensures our antibiotics claims and standards are met.

CONCLUSION

AMR is a significant healthcare challenge facing society today. AMR impacts are not only measured in direct and indirect financial costs, but also in the cost of human lives and other societal costs. Our strategy for quantifying the impact of AMR in this report reflects this by incorporating the burden on healthcare systems and loss of economic activity caused by the projected number of deaths associated with AMR. In addition, our quantification of AMR costs incorporates the costs associated with mitigation and research. The wide cost range reflects the challenges with obtaining robust global data and the inconsistencies across countries on reporting and is consistent with other estimates of the global cost of AMR. This research appears to show that one of the most significant barriers to meeting the challenge of AMR is the balance between the rewards of proactive AMR mitigation and the cost of changing established husbandry practices.

EXPANDED OVERALL FINDINGS

Our combined research confirms and begins to quantify the major drivers for AMR. Additional findings include:

- In high-income countries, the primary driver of AMR is seen to be the healthcare sector.
- In middle-income countries, agriculture is seen as the most impactful driver of AMR.
- In low-income countries, sanitation and economic inequality are seen as the most significant drivers of AMR, but the lack of data coupled with poor data quality makes measuring the impact of AMR in those countries challenging.
- The lack of reliable data associated with AMR caused by antibiotic use across agriculture limits the ability to quantify impact compared to human use.

FOOD SYSTEM INSIGHTS

The U.S. and Europe have established track records in taking regulatory action, engaging with stakeholders, including agricultural producers, and developing systems to better track antimicrobial usage and resistance. Private sector policies have also changed in these markets and industry collaborations are increasing. For the global food system, this framework of regulatory support, producer engagement, enhanced data-gathering and private sector collaboration could be shared more widely to drive accelerated change.

The following key insights reflect key findings of this research report and could help inform and support global actions including:

1. Required veterinary oversight of antibiotics in feed, through the Veterinary Feed Directive (VFD) and eliminating the use of medically important antibiotics for production purposes has been associated with decreased antibiotic use in food animals
2. Increasing veterinary oversight with a valid Veterinary Client Patient Relationship (VCPR), promotion of veterinary independence and antimicrobial labeling changes for all antibiotics will raise the bar for all companies in the food sector.
3. The challenge of individual costs and widely distributed societal benefits, a situation common in many sustainability issues, plays a key role in antimicrobial resistance. This may make it difficult to pursue AMR mitigation while remaining competitive on costs and highlights the need for strong collaboration between both the public and private sectors.
4. Improving oversight of production and distribution channels may be a cost-effective method to further reduce the agricultural impact on AMR and comply with increasingly strict regulations in the space.
5. Clear and sufficient data on antimicrobial use and resistance continue as issues. While much work has been done, challenges remain that hinder a better understanding of actual usage by species and by medication.
6. Global drivers of AMR will likely require different interventions to meet local market conditions and ensure continuous improvements.

AREAS OF OPPORTUNITY

Moving forward, we know there are areas of opportunity when it comes to making more progress around AMR and believe it will require a holistic approach among both the private and public sector. Collaboration is critical in making progress in the fight against AMR. Yum! and other companies can leverage scale to potentially influence key players such as suppliers and governments. Independent third-party oversight of antibiotic use will help ensure that reported practices are accurate.

Data & Transparency

As referenced, lack of transparent data across the public and private sector alike is an existing challenge to quantifying the economic impact of AMR. Yum! is committed to increasing our data collection and transparency across sustainability, which includes animal welfare. Having access to detailed data will help Yum! make more informed decisions but also sends a broader message on the importance of AMR. Additionally, where possible, we will encourage our partners in this space to increase the importance of data collection and reporting.

Education & Research

Education across the public and private sector is another area of opportunity to minimize AMR. Yum!'s work with ICASA, a public-private partnership on advancing antimicrobial stewardship in animal agriculture is one example of progress being made in this space.

Collaboration between the public and private sector can help drive success, educate and combat AMR. Joining the CDC AMR Global Challenge and similar efforts signify the desire to address the issue from an elevated perspective.

Animal Health & Husbandry

Responsible and judicious use of antimicrobials to help minimize antimicrobial resistance has long been a strategy in Yum!'s overall animal welfare strategy. Through improved data collection and welfare standards, the need for antimicrobials should decrease.

At Yum!, we take a thoughtful, comprehensive health management approach to our AMR programs which may necessitate the use of antibiotics for animal health. We share concerns regarding the rising threat of AMR and support One Health, a holistic, multi-sectoral, long-term effort to combat AMR by the WHO, FAO, OIE and other key stakeholders.

Public Policy

National, regional and global policies should address the complex factors driving AMR. Policies should be anchored in science-based evidence that takes public risks and benefits into consideration. Short-term and long-term impacts are also important areas to review when setting policies. Lobbying and supportive efforts on the complex topic of AMR go hand in hand with education. It is apparent that efforts will differ across nations and regions, as the specific challenges vary by country.

Yum!'s efforts to impact this through lobbying, political influence, educational activities and other expenditures could support a positive impact on the feasibility of AMR mitigation efforts moving forward. Currently, there has been some momentum in the U.S. on improving the accountability and data transparency of antibiotic resistance in the food sector at the state level. California passed Bill SB27 prohibiting the routine use of animals that are not sick for either growth promotion or disease prevention and requiring tracking of antibiotics used in feed which went into effect on January 1, 2018. Maryland passed a similar bill in 2019. There is no data yet to determine the effects these laws may have on AMR.

To expedite progress, policies should support areas where there is existing momentum, for example, removal of human use antibiotics from specific commodities (such as poultry) and environments. Next steps would be to tackle other areas like pork and beef which present additional and species-specific production challenges.

Our research on how AMR is derived for each income at the country level should influence the solutions used within the respective country. One recommendation is pulling learnings on policies from high-income countries and global governing bodies to low-income countries while accounting for logistics challenges.

Awareness for AMR has been increasing and national and international government bodies have started to implement mitigation strategies. Our research indicates that large, concerted efforts coordinated by governments and companies can greatly reduce AMR costs. Further, consumers are increasingly aware of AMR, and have a positive view of brands that pursue AMR mitigation. Private food companies have a unique opportunity to join in with policies and mitigation strategies to synergize with existing plans from governments.

REFERENCES

1. Bristol, N. (2020). The U.S. Government and Antimicrobial Resistance. Washington: Center for Strategic & International Studies. https://www.csis.org/analysis/us-government-and-antimicrobial-resistance
2. CDC, 2019. Antibiotic Resistance Threats in the United States (2019). Atlanta, GA: U.S. Department of Health and Human Services, CDC. https://www.cdc.gov/drugresistance/pdf/threats-report/2019-ar-threats-report-508.pdf
3. CDC, 2018. Choosing a Drug to Prevent Malaria. https://www.cdc.gov/malaria/travelers/drugs.html
4. Center for Food Safety, (2021). Chain Reaction VI: How Top Restaurants Rate on Reducing Antibiotic Use in their Beef Supply Chains. https://www.nrdc.org/sites/default/files/chain-reaction-vi-restaurants-antibiotic-use-2021-execsum.pdf
5. Criscuolo, N. G., Pires, J., Zhao, C., & Van Boeckel, T. P. (2021). resistancebank.org, an open-access repository for surveys of antimicrobial resistance in animals. Scientific Data, 8(1). https://doi.org/10.1038/s41597-021-00978-9
6. Dadgostar, P. (2019). Antimicrobial Resistance: Implications and Costs. Infection and Drug Resistance, Volume 12, 3903–3910. https://doi.org/10.2147/idr.s234610
7. Dillon, M. E. (2020). The Impact of Restricting Antibiotic Use in Livestock: Using a 'One Health' Approach to Analyze Effects of the Veterinary Feed Directive. Master's thesis, Harvard Extension School. https://nrs.harvard.edu/URN-3:HUL.INSTREPOS:37365628
8. Eriksen, J., Björkman, I., Röing, M., Essack, S. Y., & Stålsby Lundborg, C. (2021). Exploring the One Health Perspective in Sweden's Policies for Containing Antibiotic Resistance. Antibiotics, 10(5), 526. https://doi.org/10.3390/antibiotics10050526
9. European Centre for Disease Prevention and Control (ECDC), European Food Safety Authority (EFSA) and European Medicines Agency (EMA) (2021). Third joint inter-agency report on integrated analysis of consumption of antimicrobial agents and occurrence of antimicrobial resistance in bacteria from humans and food-producing animals in the EU/EEA, JIACRA III. 2016–2018. Stockholm, Parma, Amsterdam: ECDC, EFSA, EMA. https://www.ecdc.europa.eu/en/publications-data/third-joint-interagency-antimicrobial-consumption-and-resistance-analysis-report
10. FAIRR (2021). $47-Billion Animal Health Sector Fuelling Irresponsible Antimicrobial Use in Meat Supply Chains [Press Release]. https://www.fairr.org/article/animal-health-sector-fuelling-irresponsible-antimicrobial-use-in-meat-supply-chains/
11. FAO, OIE, WHO. 2010. The FAO-OIE-WHO Collaboration Sharing responsibilities and coordinating global activities to address health risks at the animal-human-ecosystems interfaces. A Tripartite Concept Note. https://www.who.int/foodsafety/zoonoses/final_concept_note_Hanoi.pdf
12. FDA (2017). FDA Announces Implementation of GFI #213, Outlines Continuing Efforts to Address Antimicrobial Resistance [Press Release]. https://wayback.archive-it.org/7993/20190423131636/https://www.fda.gov/AnimalVeterinary/NewsEvents/CVMUpdates/ucm535154.htm
13. FDA (2019). FDA Center for Veterinary Medicine 2019 Summary Report on Antimicrobials Sold or Distributed for Use in Food-Producing Animals. https://www.fda.gov/media/144427/download
14. FDA (2021). Timeline of FDA Action on Antimicrobial Resistance. https://www.fda.gov/media/144427/download
15. Freifeld, C. C., Mandl, K. D., Reis, B. Y., & Brownstein, J. S. (2008). HealthMap: Global Infectious Disease Monitoring through Automated Classification and Visualization of Internet Media Reports. Journal of the American Medical Informatics Association, 15(2), 150–157. https://doi.org/10.1197/jamia.m2544
16. Holmes, A. H., Moore, L. S. P., Sundsfjord, A., Steinbakk, M., Regmi, S., Karkey, A., Guerin, P. J., & Piddock, L. J. V. (2016). Understanding the mechanisms and drivers of antimicrobial resistance. The Lancet, 387(10014), 176–187. https://doi.org/10.1016/s0140-6736(15)00473-0
17. Howard, A., O'Donoghue, M., Feeney, A., & Sleator, R. D. (2012). Acinetobacter baumannii. Virulence, 3(3), 243–250. https://doi.org/10.4161/viru.19700
18. Innes, G., Randad, P., Korinek, A., Davis, M., Price, L., So, A., & Heaney, C. (2019). External Societal Costs of Antimicrobial Resistance in Humans Attributable to Antimicrobial Use in Livestock. National Bureau of Economic Research. https://doi.org/10.3386/w26189
19. Iskandar, K., Molinier, L., Hallit, S., Sartelli, M., Hardcastle, T. C., Haque, M., Lugova, H., Dhingra, S., Sharma, P., Islam, S., Mohammed, I., Naina Mohamed, I., Hanna, P. A., Hajj, S. E., Jamaluddin, N. A. H., Salameh, P., & Roques, C. (2021). Surveillance of antimicrobial resistance in low- and middle-income countries: a scattered picture. Antimicrobial Resistance & Infection Control, 10(1). https://doi.org/10.1186/s13756-021-00931-w
20. National Institute for Public Health and the Environment (2021). NethMap 2021: Consumption of Antimicrobial Agents and Antimicrobial Resistance Among Medically Important Bacteria in the Netherlands. Amsterdam: National Institute for Public Health and the Environment, Ministry of Health, Welfare and Sport. https://www.wur.nl/nl/show/Nethmap-MARAN-2021.htm
21. Nicholson, A., Pavlin, J., Bluckley, G. et al., editors. (2020). National Academies of Sciences, Engineering, and Medicine; Health and Medicine Division; Board on Global Health; Forum on Microbial Threats. Washington (DC): National Academies Press (US); 2020 May 26. https://www.ncbi.nlm.nih.gov/books/NBK560426/
22. Nhung, N. T., Chansiripornchai, N., & Carrique-Mas, J. J. (2017). Antimicrobial Resistance in Bacterial Poultry Pathogens: A Review. Frontiers in Veterinary Science, 4. https://doi.org/10.3389/fvets.2017.00126
23. O'Neill, J. (2016). Tackling Drug-Resistant Infections Globally: Final Report and Recommendations. London: Government of the United Kingdom. https://amr-review.org/sites/default/files/160518_Final%20paper_with%20cover.pdf
24. Peltola, H. (1999). Prophylaxis of bacterial meningitis. Infectious Disease Clinics of North America (Vol. 13, Issue 3, 685–710). https://doi.org/10.1016/s0891-5520(05)70101-x

25. Queenan, K., Häsler, B., & Rushton, J. (2016). A One Health approach to antimicrobial resistance surveillance: is there a business case for it? International Journal of Antimicrobial Agents, 48(4), 422–427. https://doi.org/10.1016/j.ijantimicag.2016.06.014

26. Rabello, R. F., Bonelli, R. R., Penna, B. A., Albuquerque, J. P., Souza, R. M., & Cerqueira, A. M. F. (2020). Antimicrobial Resistance in Farm Animals in Brazil: An Update Overview. Animals, 10(4), 552. https://doi.org/10.3390/ani10040552

27. Rossato, L., Negrão, F. J., & Simionatto, S. (2020). Could the COVID-19 pandemic aggravate antimicrobial resistance? American Journal of Infection Control, 48(9), 1129–1130. https://doi.org/10.1016/j.ajic.2020.06.192

28. Saleem, Z., Godman, B., Azhar, F., Kalungia, A. C., Fadare, J., Opanga, S., Markovic-Pekovic, V., Hoxha, I., Saeed, A., Al-Gethamy, M., Haseeb, A., Salman, M., Khan, A. A., Nadeem, M. U., Rehman, I. U., Qamar, M. U., Amir, A., Ikram, A., & Hassali, M. A. (2021). Progress on the national action plan of Pakistan on antimicrobial resistance (AMR): a narrative review and the implications. Expert Review of Anti-Infective Therapy, 1–23. https://doi.org/10.1080/14787210.2021.1935238

29. Schoenmakers, K. (2020). How China is getting its farmers to kick their antibiotics habit. Nature, 586(7830), S60–S62. https://doi.org/10.1038/d41586-020-02889-y

30. Singer, A. C., Shaw, H., Rhodes, V., & Hart, A. (2016). Review of Antimicrobial Resistance in the Environment and Its Relevance to Environmental Regulators. Frontiers in Microbiology, 7. https://doi.org/10.3389/fmicb.2016.01728

31. Smith, R., & Coast, J. (2013). The true cost of antimicrobial resistance. BMJ, 346(mar11 3), f1493–f1493. https://doi.org/10.1136/bmj.f1493

32. Smits, C.H.M., Li, D., Patience, J.F. and den Hartog, L.A. (2021). Animal nutrition strategies and options to reduce the use of antimicrobials in animal production. FAO Animal Production and Health Paper No. 184. Rome, FAO. https://doi.org/10.4060/cb5524en

33. Speksnijder, D. C., Mevius, D. J., Bruschke, C. J. M., & Wagenaar, J. A. (2014). Reduction of Veterinary Antimicrobial Use in the Netherlands. The Dutch Success Model. Zoonoses and Public Health, 62, 79–87. https://doi.org/10.1111/zph.12167

34. Swedres-Svarm (2020). Sales of antibiotics and occurrence of resistance in Sweden. Solna/Uppsala ISSN1650-6332. https://www.sva.se/media/8d9678c390929e9/swedres_svarm_2020.pdf

35. Teale, C. J. (2002). Antimicrobial resistance and the food chain. Journal of Applied Microbiology, 92: 85S-89S. PMID: 12000617

36. Tiseo, K., Huber, L., Gilbert, M., Robinson, T. P., & Van Boeckel, T. P. (2020). Global Trends in Antimicrobial Use in Food Animals from 2017 to 2030. Antibiotics, 9(12), 918. https://doi.org/10.3390/antibiotics9120918

37. UK-VARSS (2019). UK Veterinary Antibiotic Resistance and Sales Surveillance Report (UK-VARSS 2018). New Haw, Addlestone: Veterinary Medicines Directorate. https://doi.org/10.3390/antibiotics9120918

38. United Nations (2016). At UN, global leaders commit to act on antimicrobial resistance [Press Release]. https://news.un.org/en/story/2016/09/539912-un-global-leaders-commit-act-antimicrobial-resistance

39. Van Boeckel, T. P., Pires, J., Silvester, R., Zhao, C., Song, J., Criscuolo, N. G., Gilbert, M., Bonhoeffer, S., & Laxminarayan, R. (2019). Global trends in antimicrobial resistance in animals in low- and middle-income countries. Science, 365(6459), eaaw1944. https://doi.org/10.1126/science.aaw1944

40. Verraes, C., Van Boxstael, S., Van Meervenne, E., Van Coillie, E., Butaye, P., Catry, B., de Schaetzen, M.-A., Van Huffel, X., Imberechts, H., Dierick, K., Daube, G., Saegerman, C., De Block, J., Dewulf, J., & Herman, L. (2013). Antimicrobial Resistance in the Food Chain: A Review. International Journal of Environmental Research and Public Health, 10(7), 2643–2669. https://doi.org/10.3390/ijerph10072643

41. Vikesland, P., Garner, E., Gupta, S., Kang, S., Maile-Moskowitz, A., & Zhu, N. (2019). Differential Drivers of Antimicrobial Resistance across the World. Accounts of Chemical Research, 52(4), 916–924. https://doi.org/10.1021/acs.accounts.8b00643

42. Wall, B., Marshall L., Mateus A., Pfeiffer D.U., et al. (2016). Drivers, Dynamics and Epidemiology of Antimicrobial Resistance In animal production. Rome, FAO, ISBN: 978-92-5-109441-9. http://www.fao.org/publications/card/en/c/d5f6d40d-ef08-4fcc-866b-5e5a92a12dbf/

43. World Health Organization (2017a). What is 'One Health'? [Press Release]. https://www.who.int/news-room/q-a-detail/one-health

44. World Health Organization (2017b). Pakistan: Antimicrobial resistance national action plan [Press Release]. https://www.who.int/publications/m/item/pakistan-antimicrobial-resistance-national-action-plan

45. World Health Organization (2019). Cambodia launched multi-sectoral action plan for guiding national control of antimicrobial resistance [Press Release]. https://www.who.int/publications/m/item/pakistan-antimicrobial-resistance-national-action-plan

46. World Health Organization (2020). World leaders join forces to fight the accelerating crisis of antimicrobial resistance [Press Release]. https://www.who.int/cambodia/news/detail/23-12-2019-cambodia-launched-multi-sectoral-action-plan-for-guiding-national-control-of-antimicrobial-resistance

47. World Bank (2017). "Drug-Resistant Infections: A Threat to Our Economic Future." Washington, DC: World Bank. https://documents1.worldbank.org/curated/en/323311493396993758/pdf/final-report.pdf

48. Wu, Z. (2017). Balancing food security and AMR. China Agricultural Economic Review, 9(1), 14–31. https://doi.org/10.1108/caer-07-2016-0106

49. Yang, H., Paruch, L., Chen, X., van Eerde, A., Skomedal, H., Wang, Y., Liu, D., & Liu Clarke, J. (2019). Antibiotic Application and Resistance in Swine Production in China: Current Situation and Future Perspectives. Frontiers in Veterinary Science, 6. https://doi.org/10.3389/fvets.2019.00136

50. Yum! (2020). Global Citizenship & Sustainability Report. Kentucky: Yum! Brands. https://www.yum.com/wps/wcm/connect/yumbrands/b9c0d469-b459-483f-b87b-aba32184002e/2020+Citizenship+Report_FINAL-spreads-v5.pdf?MOD=AJPERES&CVID=nHKp.Yx

PRIMARY PRESCOUTER RESEARCH

PreScouter engaged in primary survey research on estimates of incidence, market impact, and future trends with analysts, scientists and physicians. These results represent the synthesized results of this study.

EXPERT PANEL INTERVIEWS

Panel of 12 subject matter experts identified by PreScouter.

Profession	Operational Setting	Research Area
Executive Director	Australia	Molecular Bioscience, Medicine & Health
Professor	Singapore	Public Health
Senior Research Manager	U.K.	Antimicrobial Resistance and Global Burden of Diseases
Professor	Sweden	Animal Infection Prevention
Professor	U.S.	Molecular Epidemiology
Research Associate	U.K.	Infection Control
Professor	Scotland	Antimicrobial Stewardship
Head of R&D	U.K.	Medical Microbiology & Infection Control
Senior Researcher	U.K.	Health Economics
Assistant Professor	Switzerland	Epidemiology
Professor	U.S.	Agricultural Economics
Senior Consultant	U.S.	Infectious Disease Epidemiology

ABBREVIATIONS & ACRONYMS

AMR – Antimicrobial Resistance

CAGR – Compound Annual Growth Rate

CDC – Centers for Disease Control & Prevention

ECDC – European Centre for Disease Prevention & Control

EFSA – European Food Safety Authority

EMA – European Medicines Agency

FAIRR – Farm Animal Investment Risk & Return

FAO – Food & Agriculture Organization of the UN

FDA – Food & Drug Administration

GDP – Gross Domestic Product

ICASA – International Consortium for Antimicrobial Stewardship in Agriculture

MRSA – Methicillin-resistant Staphylococcus aureus

OIE – World Organisation for Animal Health

OTC – Over-the-counter

PVP – USDA Process Verified Program

UK-VARSS – United Kingdom Veterinary Antimicrobial Resistance & Sales Surveillance

UN – United Nations

USDA – U.S. Department of Agriculture

USRSB – U.S. Roundtable for Sustainable Beef

VCPR – Veterinarian Client Patient Relationship

VFD – Veterinary Feed Directive

WHO – World Health Organization

ABOUT YUM! BRANDS, INC.

Yum! Brands, Inc., based in Louisville, Kentucky, has over 52,000 restaurants in more than 150 countries and territories, operating the Company's brands – KFC, Pizza Hut and Taco Bell – global leaders of the chicken, pizza and Mexican-style food categories. The Company's family of brands also includes The Habit Burger Grill, a fast-casual restaurant concept specializing in made-to-order chargrilled burgers, sandwiches and more. Yum! Brands was included on the 2021 Bloomberg Gender-Equality Index. In 2020, Yum! Brands was named to the Dow Jones Sustainability Index North America and was ranked among the top 100 Best Corporate Citizens by 3BL Media.