2024 YUM! ANTIMICROBIAL RESISTANCE REPORT

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PROLOGUE

In 2021, as part of our antimicrobial resistance (AMR) journey we produced 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

The report production was guided by key principles that included being grounded in evidence-based, sound science and balancing the complex nature and increased pressure in the AMR space. The original research in the 2021 report was conducted by PreScouter.

By 2024, it was clear that the report needed revision. For this, we commissioned a third-party AMR expert to review and update the original research including adding new data and literature, and expanding the scope to incorporate international information.

The content contained in the report is intended to be a snapshot of the current state of research and isn't designed as 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 on programs and policies to positively impact the global AMR scenario. In addition, we are committed to being good stewards 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 and welfare. 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 (WOAH) and other key stakeholders.

EXECUTIVE SUMMARY

Antimicrobial resistance (AMR) from the misuse and overuse in humans, animals, plants, and the environment is acknowledged as a major global threat and crisis by international authorities. AMR affects countries in all regions and at all income levels and is a leading cause of death globally (WHO). At the same time, antimicrobials play a critical role in treating diseases of food-producing animals, helping to ensure food security.

This report is intended to evaluate the global costs associated with AMR and better understand the international 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 originally conducted by PreScouter, combined data from existing research articles, policy white papers and market research reports with research conducted through interviews with SMEs. The 2021 research portion of this investigation included a panel of 12 experts on global health, epidemiology, infection control, medical microbiology and health economics.

The global cost of AMR, including direct and indirect costs, is significant and these costs are largely driven by the increase in infections caused by antibiotic resistant bacterial species AMR contributes to costs worldwide through an increased strain on the medical system, putting many of the gains of modern medicine at risk.

While quantifiable risks and costs can be approximated, AMR attribution is challenging. It is still unclear how many human deaths linked to AMR originated in animals (WOAH 2024a).

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, invites overuse and misuse. While research indicates that a major driver of AMR is medical misuse and overuse of antibiotics in people, international animal organizations agree that antimicrobials misuse in the livestock sector is a major concern as a risk for emergence and spread of antimicrobial resistant micro-organisms (FAO 2024). The following are identified as key drivers in each economic category:

- Misuse and overuse 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 and lack of a legal framework on the use of antimicrobials as their largest drivers of AMR.
- Sanitation, environmental, and governance issues in low-income countries are major issues that contribute to poor access and misuse.

Although the problem of AMR cannot be solved with quick-fix solutions, reducing the need for antimicrobials and limiting the emergence of resistant pathogens is critical. As AMR has multiple drivers and needs to be tackled on many fronts, a One Health approach (interconnecting and humans, other animals, and their shared environments at all levels to achieve thriving health for all) is essential to ensure that all sectors and stakeholders communicate and work effectively together. Antimicrobial-resistant microorganisms can develop in our food chain and move between animals, humans, and the environment. 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.

During the COVID-19 pandemic, the detection and reporting of antimicrobial resistance data slowed tremendously and the outbreak halted some progress on combatting AMR. The pandemic had repercussions on AMR costs and that it will take some time to fully evaluate the impact on AMR. However, available data show an alarming increase in resistant infections starting during hospitalization, growing at least 15% from 2019 to 2020 (CDC 2022).

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, although anti-fungal resistance is also growing. 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 lowered costs have mostly been deployed on a national rather than a regional level.** In the U.S., the Food and Drug Administration (FDA) 2017 finalized guidance on restricted antibiotic use in livestock production and in 2023 published a proposed new ranking criteria for determining the degree of importance in human medicine of antimicrobial drug classes and applied that criteria to revise the ranking of antimicrobial drug classes. Antibiotics are now available only by veterinary prescription. Consequently, the 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. In 2022, China banned all antibiotic growth promoters, except herbal medicines, although the results of that action are still unknown (Rahman 2022).
- **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 in the poultry sector, and companies are removing the use of antibiotics from their entire supply chain without government requirements. Several companies have instituted policies to remove using any antibiotics important to human medicine in their animal health plans.
- **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.** 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. Information on the health and economic impacts of livestock-related AMR in low-income countries is still lacking, with only 89 countries with systems in place to collect data on the use of antimicrobials in animals.

- **Similarly, there is a lack of reliable data from the beef sector.** This is in part due to the fragmented nature of beef production, with considerable number and variety of farms and ranches where cattle live from birth to slaughter. Further complicating the issue, beef is derived from both exclusive beef production and dairy production. The two industries have accounting differences for antibiotic use that are nearly impossible to reconcile.

- **A One Health approach, including health, agriculture, food, and the environment will be needed.** Each sector can each take on leadership in addressing AMR. Collaborations and coordination between sectors can also be powerful and effective. However, relying on coordination across sectors can stifle action.

- **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 Transformational Strategies for Farm Output Risk Mitigation (TRANSFORM), a private-sector-led USAID Global Health Security activity. The International Poultry Council (IPC) is leading the adoption of industry-wide principles around antimicrobial use stewardship within the poultry meat industry.

- **The outbreak of COVID-19 has put the global healthcare sector under extreme pressure.** When COVID-19 cases increased in hospitals, so did antibiotic use. The increased use of antibiotics for COVID-19 secondary infections and reduced comprehensive prevention practices, led to increased AMR (CDC 2022).

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 one of the greatest global health challenges of our time, becoming a leading cause of death globally (Murray 2022). In 2017, the World Bank estimated that by 2050, unchecked AMR could wipe away 3.8 % of global gross domestic product each year and push 28 million people into poverty (World Bank 2024). The International Quadripartite collaboration group on AMR, comprised of WHO, the UN Environment Programme (UNEP), the Food and Agricultural Organization (FAO) and the World Organization for Animal Health (WOAH), have developed a One Health approach in the face of this issue (FAO 2023).

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 such as TRANSFORM, the Quadripartite collaborative Multi-Partner Trust Fund, and support of the Global Leaders Group on AMR (FAO 2023) efforts have just begun to move from proposal to concrete and enforceable policy.

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.

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). In the U.S, as of 2017, infection prevention and control efforts contributed to reduced deaths from antimicrobial-resistant infections by 18% overall and by nearly 30% in hospitals. However, the pandemic has undone much of this progress and resistant hospital-onset infections and deaths both increased at least 15% during the first year of the pandemic (CDC 2022). 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).

AMR Drivers	Mitigation Steps
Antimicrobial Use (misuse/overuse)	Improve/judicious antimicrobial use
Lack of oversight framework	Detecting and deterring counterfeit drugs
Suboptimal diagnostics	Reliable data
Poor sanitation & Water Quality	Improved Sanitation
Governmental Factors	Education & Awareness
Environmental Factors	Enhanced biosecurity

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

DRIVERS OF AMR

Although antibiotic use is crucial to combat bacterial infection, the misuse and overuse of antimicrobials in humans, animals and plants are the main drivers in the development of drug-resistant pathogens. The consequences are exacerbated by poverty and inequality, and low- and middle-income countries are most affected and have the highest levels of AMR (WHO 2024). Historically, AMR in humans was attributed to overuse in human medicine. Both overuse and misuse of antibiotics in hospitals and care settings, together with over-the-counter (OTC) access of antibiotics, have been well-studied. Several papers report the major impact of these drivers on the development and spread of resistant microbes within high-income countries (Vikesland et al. 2019). While AMR is a multisectoral issue, sector-specific entry points are important for mobilizing prompt action.

The use of antimicrobials in agriculture contributes to the spread of AMR and undermines the effectiveness of veterinary medicines. Additionally, drug-resistant infections in humans have also been tracked to foodborne or animal sources (Swartz 2002). In middle and lower-income countries, inappropriate antibiotic use is a multifaceted problem that cuts across clinical and veterinary medicine and agriculture (Otaigbe 2023). Inadequate water, sanitation, and hygiene as well as climate factors as well as misuse of antibiotics all exacerbate AMR in lower-income countries (Al Meslamani 2023).

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, and prevention but are not allowed for production. The use of antimicrobials for growth promotion was still practiced in at least 41 countries in 2021 (WOAH 2023a). On the other hand, less than 20% of antimicrobials used in animals were of highest priority and critical importance for human health in 2019 (WAOH 2023b).

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. 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, 30% to 90% of the antibiotics administered to animals in the feed or water are released back into the environment in 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).

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 and environmental 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).

IMPACT OF AMR ON SOCIETY

POTENTIAL GLOBAL ECONOMIC IMPACT

In 2016, the World Bank estimated that, left unchecked, loss of life and productivity due to AMR could cost the global economy 3.8% of its annual gross domestic product by 2050. The impact of AMR will be more severe in low-income countries, potentially pushing an additional 28 million people into extreme poverty by 2050 (Rupasinghe 2024). The global burden of animal diseases due to AMR is unknown because no data are available (WOAH 2024b).

The findings of the Global Research on Antimicrobial Resistance Study show that drug-resistant bacterial infections contributed to almost five million human deaths in 2019, making AMR a leading cause of death globally. According to the World bank, in 2019, drug-resistant infections were a significant contributor to mortality, with an estimated 1.27 million people losing their lives due to AMR infections.

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). CDC has provided best estimates for costs associated with AMR for specific pathogens. 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

- $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. (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. 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 and continued 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 have been slightly rising since 2018, after significant initial decreases in antibiotic use in 2017 (FDA 2024). 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 99,502 tonnes in 2020, and this is projected to grow to 107,472 tonnes by 2030. Hotspots of antimicrobial use were overwhelmingly in Asia, with China, Brazil, India, USA, and Australia as the top 5 consumers in 2020. Together these countries made up 58% of global AMU (Mulchandani 2023). 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 causative 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 four thematic areas are reducing infections; strengthening monitoring and surveillance of AMR and antimicrobial use (AMU); improving access and the rational use of antimicrobials; and strengthening sectoral and multisectoral coordination and governance.

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

In 2022. the FAO, UNEP, WHO, and WOAH—known as the Quadripartite—joined to develop the Antimicrobial Resistance Multi-Stakeholder Partnership Platform to ensure the growing threats and impacts of antimicrobial resistance are addressed globally. This international forum brings together all perspectives through a One Health approach, for a shared vision to improve coordination of efforts by many stakeholders. In 2024, the key recommendations for action from that partnership are comprised of 10 actionable and measurable steps:

1. Enhance One Health collaboration on AMR through multi-stakeholder coordination
2. Accelerate the implementation of AMR National Action Plans (NAPs) for all countries
3. Strengthen capacity for AMR efforts by mobilizing sustainable financing
4. Strengthen health systems for better human, animal, and environmental health.
5. Better leverage preventive measures such as vaccination to increase access to them
6. Strengthen sector-specific AMR and antimicrobial use (AMU) surveillance
7. Transform agrifood systems to significantly reduce AMU while optimizing animal health and welfare
8. Ensure universal access to quality essential medicines, vaccines and diagnostics for humans and animals.
9. Encourage high-income countries and other stakeholders to commit to sustainable antimicrobial research and development (R&D),
10. Prevent and address the drivers, sources and challenges of the environmental dimension of AMR.

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

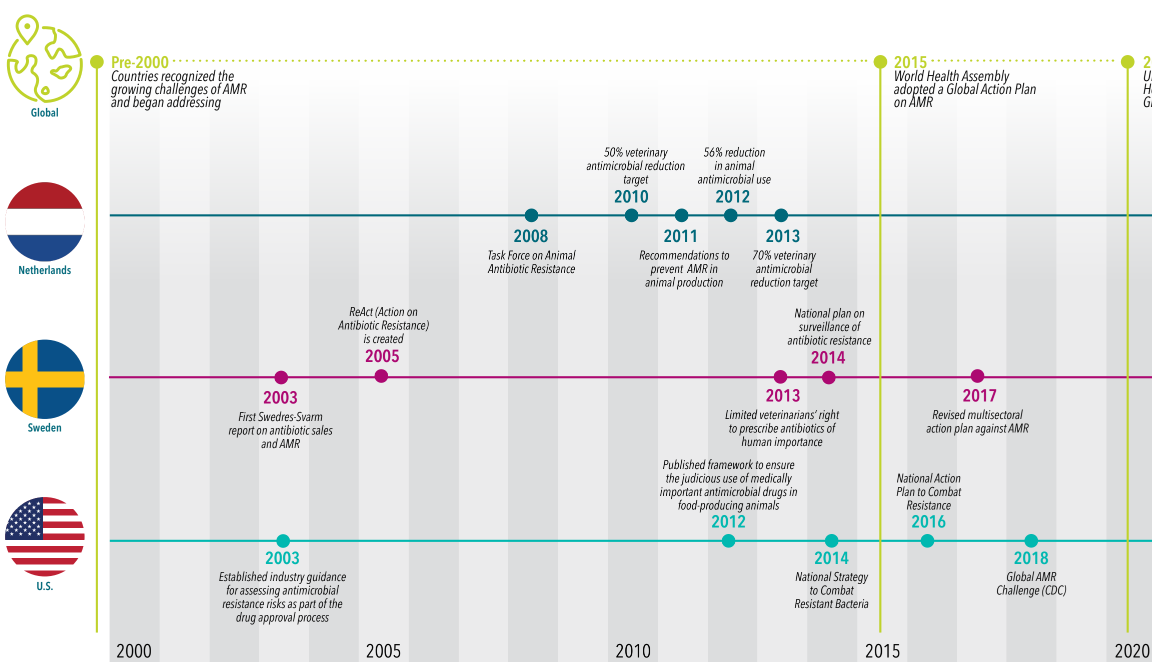

Figure 5. *Overview of some of the AMR mitigation plans, including regulation and reporting, implemented by the Netherlands, Sweden and the U.S. governments in the last two decades. This chart is not comprehensive and only a snapshot of some of the key milestones that have occurred and countries that 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 from over-the-counter (OTC) medications to require veterinary oversight, including revising the Veterinary Feed Directive (VFD) (FDA 2017). These measures resulted in the requirement that the use of these drugs be authorized by a licensed veterinarian, thus curbing their use. In 2023, FDA published a proposed new ranking criteria for determining the degree of importance in human medicine of antimicrobial drug classes and applied that criteria to revise the ranking of antimicrobial drug classes. Chickens are the only category where there has been an overall decline since 2017, when the FDA regulations first took effect.

Medically important antimicrobial drug sales for use in food producing animals, from figures issued by FDA in 2024

Species	2017 Annual Totals (kg)	2018 Annual Totals (kg)	2019 Annual Totals (kg)	2020 Annual Totals (kg)	2021 Annual Totals (kg)	2022 Annual Totals (kg)	2023 Annual Totals (kg)
Cattle	2,333,839	2,517,277	2,529,281	2,449,441	2,460,766	2,569,381	2,513,928
Swine	2,022,932	2,374,277	2,582,399	2,451,382	2,529,800	2,658,047	2,682,301
Chicken	268,047	221,774	192,964	141,793	158,342	152,350	145,809
Turkey	670,831	671,108	644,921	690,841	659,431	725,286	596,928
Other*	263,564	247,753	239,694	268,600	181,383	140,656	189,027
Total	**5,559,212**	**6,032,298**	**6,189,269**	**6,002,056**	**5,989,721**	**6,245,720**	**6,127,993**

**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.*

Importance of Key AMR Mitigation Strategies

To develop a deeper understanding of critical mitigation strategies for AMR, in 2021 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.

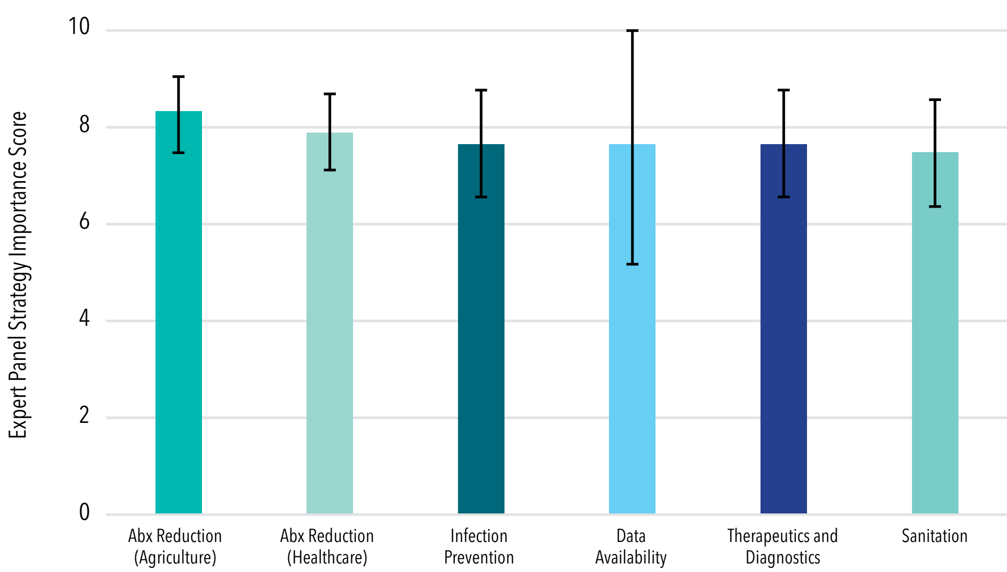

Figure 6. *Expert panel evaluation of the relative importance of the main AMR mitigation steps according to the One Health Approach with a 1 indicating low importance and 10 indicating high importance. Importance scoring by our expert panel reveals the relevant contribution of all mitigation steps (Expert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

Antibiotic consumption patterns in low-income countries have displayed a notable upward trend (Kanan 2023). A limited regulatory framework, lack of accessible diagnostics, sanitation issues, and counterfeit drugs 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). Peruvian veterinarians reported that inappropriate AMU is widespread and largely driven by availability of antibiotics, competition with other veterinarians, economic constraints of farmers, and limited knowledge of animal diseases among farmers (Hedman 2020).

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. There has been movement from no antibiotics ever to use of nonmedically important to human medicine antibiotics. This minimized the often unintended deleterious consequences for animal health and welfare of no antibiotics ever.

In 2021, USAID launched Transformational Strategies for Farm Output Risk Mitigation (TRANSFORM), a five-year, $33 million private sector-led project to address emerging infectious diseases and AMR in animal production value chains in Asia and Africa. It follows the International Poultry Council's (IPC) Best Practices Guidance to Reduce the Need for Antibiotics in Poultry Production. That approach emphasizes actions that ensure adequate housing, environment, biosecurity, hygiene, nutrition, a health and welfare care plan, as well as antibiotic uses to avoid.

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.

Global Challenges to Mitigation

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). Lower income countries may require unique interventions due to their unique structural, cultural, and socioeconomic factors affecting AMR emergence.

Further, veterinary service policy related to antimicrobial use is often outdated or nonexistent further limiting the efficacy of antimicrobial stewardship. Political governance can be another obstacle. Post-market review of antimicrobials rarely exists and fraudulent veterinary antimicrobial products regularly enter markets, leading to serious impacts of therapeutic efficacy and contributing to AMR (Dápas 2018).

In India, for example, treatment of animals by farmers themselves and lack of proper recording makes it difficult to gather accurate data on antimicrobial use, India has no nationwide database on AMU surveillance, so the burden of AMR in India is unknown (Metua 2020). Circumvention of antibiotic use legislation occurs through numerous formal and informal routes due to limited public sector power. This limited power to enforce existing antibiotic legislation and guide antibiotic usage and major gaps in livestock healthcare services make attempts to curb informal prescribing unsustainable (Hennessey 2023).

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, WOAH 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. All of Yum!'s U.S. meat and poultry suppliers are required to 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	Complete
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	In progress

Yum! is part of the One Health endeavor which is a multi-sectoral, long-term effort to combat AMR by the WHO, FAO, WOAH 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! brands formally endorsed TRANSFORM and the IPC antimicrobial use stewardship principles in 2024, including the principle that antimicrobials critically important for human medicine should be used for therapeutic purposes only and under a supervising veterinarian's diagnosis and oversight.

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

Yum! uses the USDA Process Verified Program (PVP), third party auditing system. This verification process ensures our antibiotics claims and standards are met. Yum! also supports the U.S. Pork Board's guidance to promote antibiotics responsibility for U.S. pork producers.

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, animal 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. 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. Additional challenges with our work in low-and-middle income countries is a lack of access, infrastructure and resources.

EXPANDED OVERALL FINDINGS

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

- The need for a One Health approach incorporating human, animal and environmental health
- In high-income countries, the drivers of AMR are primarily misuse in all sectors.
- In middle-income countries, poorly regulated agriculture and lack of a legal framework are seen as the most impactful drivers of AMR.
- In low-income countries, sanitation, access, 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, such as the Veterinary Feed Directive (VFD), veterinary oversight of all antimicrobials, and eliminating the use of medically important antibiotics for production purposes has been associated with decreased antibiotic use in chickens
2. 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.
3. 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.
4. 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.
5. The 2024 United Nations General Assembly high-level meeting on antimicrobial resistance commits to ensuring the use of antimicrobials is done in a prudent and responsible manner in line with the Codex Alimentarius Antimicrobial Resistance Standards and the standards, guidance and recommendations of the World Organisation for Animal Health with the 2030 goal of reducing the quantity of antimicrobials used.

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. To that end, Yum! has endorsed international projects, such as TRANSFORM and ICASA. Yum! and other companies can continue to 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

Lack of both data and transparency 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, including 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, and TRANSFORM public- private partnerships on advancing antimicrobial stewardship in animal agriculture are examples 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, WOAH, 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 so far only sparse data, so the effects these laws may have on AMR have not yet been determined.

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.

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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

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

IPC - International Poultry Council

MRSA – Methicillin-resistant Staphylococcus aureus

OTC – Over-the-counter

PVP – USDA Process Verified Program

TRANSFORM – Transformational Strategies for Farm Output Risk Mitigation

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

UN – United Nations

UNEP- United Nations Environment Programme

USAID – United States Agency for International Development

USDA – U.S. Department of Agriculture

USRSB – U.S. Roundtable for Sustainable Beef

VCPR – Veterinarian Client Patient Relationship

VFD – Veterinary Feed Directive

WOAH - World Organisation for Animal Health

WHO – World Health Organization

ABOUT YUM! BRANDS, INC.

Yum! Brands, Inc., based in Louisville, Kentucky, and its subsidiaries franchise or operate a system of over 59,000 restaurants in more than 155 countries and territories under the company's concepts – KFC, Taco Bell, Pizza Hut and Habit Burger & Grill. The Company's KFC, Taco Bell and Pizza Hut brands are global leaders of the chicken, Mexican-style food, and pizza categories, respectively. The Habit Burger & Grill is a fast casual restaurant concept specializing in made-to-order chargrilled burgers, sandwiches and more. In 2024, CDP, a global organization that runs a leading sustainability disclosure program, ranked Yum! with Climate Change and Water Security scores of A-, and all of Yum!'s CDP scores were a B or higher. Yum! was also named to the Dow Jones Sustainability Index North America, and the company was recognized among TIME Magazine's list of Best Companies for Future Leaders, Newsweek's list of America's Most Responsible Companies and USA Today's America's Climate Leaders. Yum! also received widespread recognition in 2023, including being listed on the Bloomberg Gender-Equality Index; and Forbes' list of America's Best Employers for Diversity. In addition, KFC, Taco Bell and Pizza Hut brands were ranked in the top five of Entrepreneur's Top Global Franchises Ranking for 2023.