

THE ANIMAL HEALTH AMR R&D LANDSCAPE IN LOW- AND MIDDLE-INCOME COUNTRIES:

AN ANALYSIS OF FUNDING PATTERNS



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ABOUT THE REPORT

This report is a collaborative initiative of the International Development Research Centre (IDRC) and the Global AMR R&D Hub. In publishing this report, our two organizations hope to provide insight into investment and data gaps to inform the international community and provide evidence to help set future funding priorities in AMR research.

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Authors: Evelyn Baraké (IDRC), Renée Larocque (IDRC)

Cover photo: Kwale Village, Kangundo, Machakos, Kenya. An Indigenous Chicken and baby chicks eating at a feeder. Credit IDRC/Bartay

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The Global AMR R&D Hub was launched in May 2018, following a call from G20 Leaders, to address challenges and improve coordination and collaboration in global AMR R&D using a One Health approach. It is a global partnership currently consisting of 17 countries, the European Commission and two philanthropic foundations. The work of the Global AMR R&D Hub is steered by a Board of Members. By launching the animal component of its dynamic dashboard, the Global AMR R&D Hub is supporting the improvement of a coordination and collaboration in tackling global AMR using a One Health approach.

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INTRODUCTION

ANTIMICROBIAL RESISTANCE: A GLOBAL CHALLENGE

Antimicrobials, including antibiotics, play a critical role in the treatment of diseases of farm animals, aquatic and terrestrial. Maintaining their efficacy is essential to food security, to human health, to animal health and welfare. However, the misuse and overuse of antimicrobials, in both human and veterinary medicine, is associated with the emergence and spread of antimicrobial-resistant organisms (including bacteria) that threaten the ability to effectively treat infections in humans and animals.

The emergence and spread of AMR kill an estimated 700,000 people annually, a number which is expected to increase by a factor of 10 by 2050 (Subramanya, et al. 2021). The risk posed by AMR is likely higher in countries where legislation, regulatory surveillance and monitoring systems on the use of antimicrobials, and the prevention and control of AMR, are weak or inadequate (FAO 2016). In addition to antimicrobial misuse in humans, animals and crops, the inadequate management of pharmaceutical wastes at the sites of production have been identified as important drivers of antimicrobial resistance (AMR) in low- and middle-income countries (LMICs) (Sulis, Sayood and Gandra 2021). Though it is difficult to estimate the magnitude of the AMR problem in LMICs, there is evidence that resistance to the antimicrobials most often used for raising animals for food has significantly increased in the last 20 years (Van Boeckel, et al. 2019). The same study reports AMR resistance hotspots in Vietnam, China, Pakistan, India, Iran, Turkey, Egypt, South Africa, Mexico and Brazil, and additional emerging hotspots in southern China, central India, Morocco, Kenya, southern Brazil and Uruguay.

The contamination of animal products and the wider environment with antimicrobial-resistant bacteria is a risk factor for humans, animals, and the environment. Livestock provide food and income for roughly 1.4 billion farmers globally, including 800 million poor livestock keepers. With AMR on the rise, communities in developing countries are highly impacted by infectious disease outbreaks and loss in livestock productivity, which ultimately endangers food security and disrupts international trade. Given the inextricable links between human, animal, plant and environmental health, AMR represents a priority One Health issue.

In 2016, the UN General Assembly recognized AMR as a global threat that disproportionately affects people in LMICs. The international community was called upon to rise to the complex challenge of AMR and take urgent action. In response, a number of initiatives were launched, including the Global AMR R&D Hub, which was established as a result of the 2017 meeting of the G20 led by Germany, and the Global Leaders Group on Antimicrobial Resistance. Furthermore, since 2017, AMR has been mentioned in each annual G20 declaration.

OBJECTIVE

This report presents an analysis of international funding for animal health AMR Research and Development (R&D) since 2017. The goal of this analysis is to present an overview of investment

trends in animal health AMR research that is either funded by LMICs, directed at research institutions based in LMICs, or otherwise connected to LMICs. In presenting these trends, this report aims to highlight the types of research, pathogens, and animal health subsectors that receive the most (and the least) funding, as well as the countries and regions that these investments are connected to. These trends and their implications are further explored in the discussion section.

DATA

ANIMAL HEALTH AMR R&D INVESTMENT DATA

The data used in this analysis was provided by the [Global AMR R&D Hub](#) and can be accessed and explored using the [Dynamic Dashboard](#).¹ The Dynamic Dashboard continuously collects and presents information on investments in research projects addressing AMR investments across the One Health continuum (human, animal, plant and environmental health). It is designed to be a resource for those working in the field of AMR R&D to support evidence-based decision-making on where efforts and resources may be best allocated. It was launched in several stages, starting with human health project data, followed by animal health, and most recently, with the inclusion of plant and environmental health. In total, the Dynamic Dashboard captures 12,096 investments in research projects for a total of USD 8.91 billion in funding by 214 funders.² This analysis covers basic and applied AMR R&D investments that include an animal health component. This subset includes 1,440 separate investments in 1,241 unique projects by 120 different funders worth a total of USD 1.02 billion.

Investments are categorized using key word searches of the project abstracts. For projects with multiple participating institutions, the entire budget is allocated to the institution of the principal investigator or coordinator. To arrive at investments per year, the total budgets of all projects are distributed *pro rata* over the years of duration. Co-funded projects have been divided, whereby each funder is considered to have made a separate investment.

A summary of definitions relevant to this analysis can be found in the Appendix.³

LIMITATIONS

Currently, only the R&D supported by public funders and philanthropic organizations is included in this database. The Dynamic Dashboard and its associated database are a work in progress, and continuing efforts are being made to obtain additional data pertaining to private sector investments and from additional funders globally. In the context of this analysis, it is important to note that coverage of funders from the Southern hemisphere and LMICs is still limited. Funders and investors that have information about AMR-related R&D projects are encouraged to share them with the Global AMR R&D Hub. For more information about the collection, processing, and categorization of the data used in this analysis, please consult [this explanatory paper](#), published on the Global AMR R&D website (Global AMR R&D Hub 2020).

¹ Please consult the following page for a full list of data sources: [Data Sources – Global AMR R&D Hub \(globalamrhub.org\)](#).

² The high-level data categories developed to classify the AMR funding and investment information are described in the following paper: [Establishing the Dynamic Dashboard – Methodology for developing the categorisation fields](#).

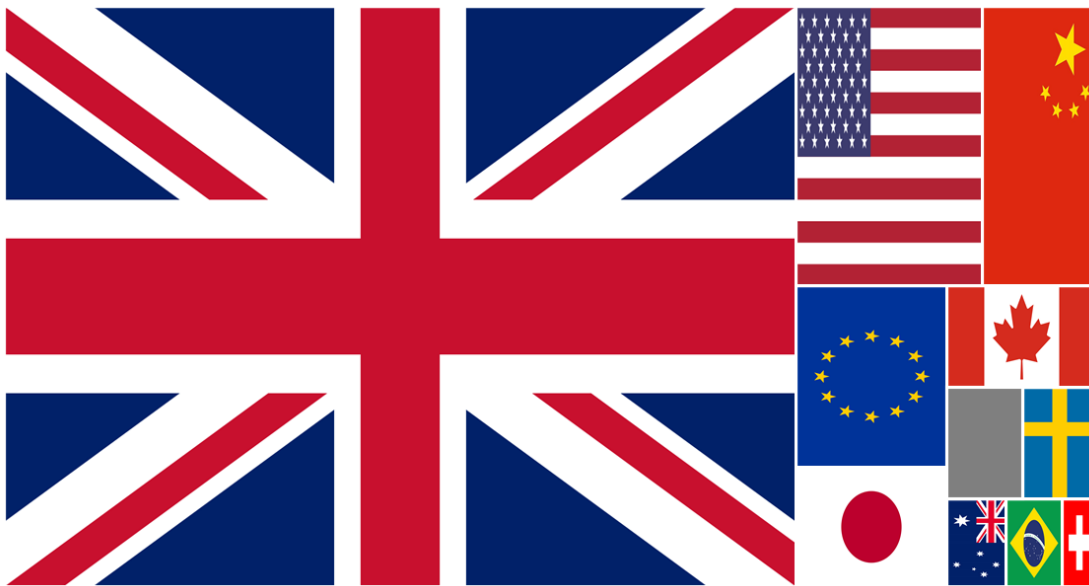
³ For a full description and list of definitions, categorizations and exclusion criteria for the Dynamic Dashboard, please see the [Dynamic Dashboard – Categories and Definitions paper](#).

ANALYSIS

WHO FUNDS ANIMAL HEALTH AMR RESEARCH?

According to the Global AMR R&D Hub's Dynamic Dashboard,⁴ recorded animal health funding comprises 11% of the USD 8.91 billion in AMR R&D funding since 2017. As a share of the animal health research investments included in the database, less than one third involves LMICs, amounting to USD 301 million since 2017. This represents 364 investments, 118 of which are currently active.

Figure 1 Share of animal health AMR R&D funding by country since 2017



Almost three quarters of all funding in animal health AMR R&D in the Dynamic Dashboard is by funding institutions based in the United Kingdom. Other countries from which the most funding originates include the United States, China, the European Union, Japan, and Canada, which together make up 95% of all funding in this space (see Figure 1 and Table 1). Most investments in Animal Health AMR R&D in the database are made by public institutions (97%), and the remaining is funded by private non-profit organizations or by joint public-private initiatives based in high-income countries (HICs).

⁴ Note that the database does not include data on private-sector-led investments; therefore, it is best considered as a database of NGO and publicly funded R&D, and that there may be information missing about funders based in LMICs and in the Global South.

Table 1 Animal health AMR R&D funding by country since 2017

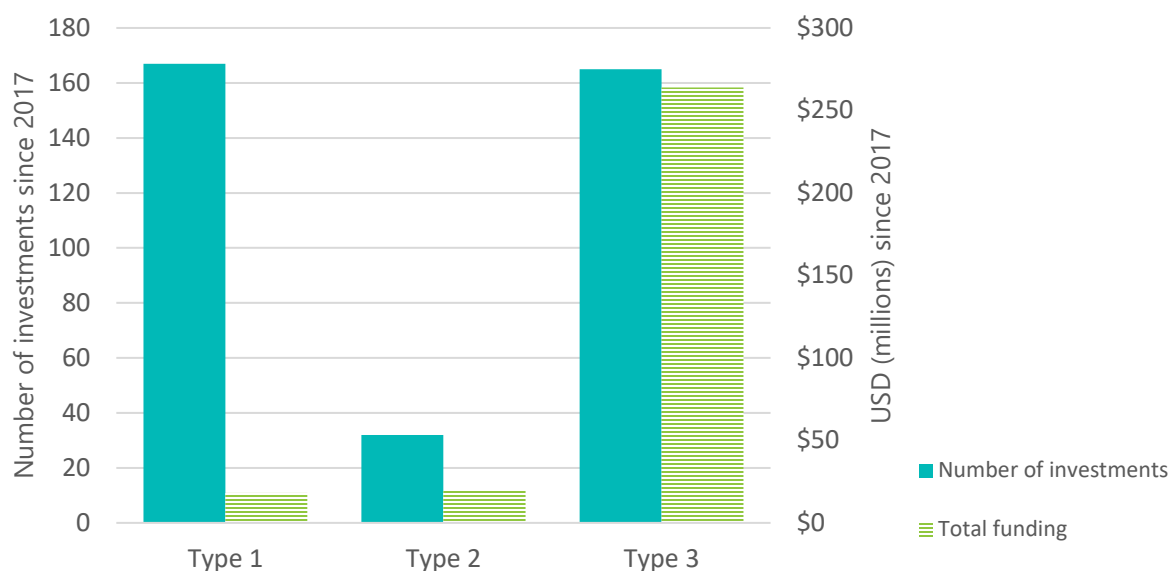
Country	Funding since 2017 (USD, millions)	Share of animal health total
United Kingdom	\$218.4	72%
United States	\$24.8	8%
China	\$15.2	5%
European Union	\$13.0	4%
Japan	\$8.6	3%
Canada	\$7.3	2%
Sweden	\$4.0	1%
Australia	\$2.5	1%
Brazil	\$2.3	1%
Switzerland	\$1.4	0%
Other	\$4.0	1%

The investments in animal health AMR R&D contained in the database are considered to involve LMICs in three ways:

- Type 1 Investments** The funding institution is based in an LMIC and the research organization to which the funding is directed is based in the same country;⁵
- Type 2 Investments** The funding institution is based in an HIC and the lead research organization is based in an LMIC; and
- Type 3 Investments** Both the funding institution and the research institution to which the funding is directed are based in HICs, and the research is relevant for at least one specified LMIC⁶, has an LMIC-based partner institution and/or takes place in an LMIC.

⁵ All animal health investments in the database with an LMIC-based funder exclusively fund research organizations based in the same country.

⁶ Usually, the LMIC(s) will be explicitly mentioned in the abstract.

Figure 2 Animal health AMR R&D Investments related to LMICs by investment type

The largest funders of animal health AMR R&D research involving LMICs in the database are presented in Table 2 below. Five of the ten largest funders are based in the United Kingdom. All of these funders are public institutions, except the Wellcome Trust, which is a private non-governmental organization.

Table 2 Largest funders of animal health AMR R&D involving LMICs since 2017

Rank	Funder	Country	LMIC-related funding (USD, millions)	Share of total
1	Fleming Fund	United Kingdom	\$111.12	37%
2	Biotechnology and Biological Sciences Research Council	United Kingdom	\$58.77	19%
3	Centers for Disease Control and Prevention	United States	\$21.23	7%
4	Medical Research Council	United Kingdom	\$19.27	6%
5	Global AMR Innovation Fund (GAMRIF)	United Kingdom	\$16.03	5%
6	European Commission	European Union	\$13.01	4%
7	Economic and Social Research Council	United Kingdom	\$9.24	3%
8	National Natural Science Foundation of China	China	\$8.54	3%
9	Japan Agency for Medical Research and Development	Japan	\$8.25	3%
10	Ministry of Science and Technology	China	\$6.67	2%
11	International Development Research Centre	Canada	\$6.65	2%
12	Australian Centre for International Agricultural Research	Australia	\$2.46	1%
13	National Institutes of Health	United States	\$2.29	1%
14	São Paulo Research Foundation	Brazil	\$2.12	1%
15	Swedish Research Council	Sweden	\$1.97	1%
16	Wellcome Trust	United Kingdom	\$1.66	1%

Type 1 Investments: LMIC-funded

Funders based in LMICs support 12% of all investments in animal health AMR R&D in the dynamic dashboard and account for 2% of total funding in this area, representing 167 investments and USD 18.2 million in funding since 2017. Of these, 30 investments remain active. However, it is important to note that this is an area of the database where significant data gaps may be present. In the context of the currently available data, countries that fund their own research are predominantly large middle-income countries. The notable outliers to the list of countries funding their own R&D in animal health AMR are Georgia⁷ and Tunisia, two relatively small middle-income countries.

The majority of this funding (84%) comes from Chinese funders, with Brazil as a distant second (13% of funding). Brazil is the leading investor in animal health AMR R&R by number of investments (49% of all type 1), followed by China (38%), and Argentina (7%). The discrepancy between the funding and investment percentages is likely due to data limitations, as much of the investment data from Brazil does not include budgetary information.

TYPE 1 INVESTMENTS AT A GLANCE

LMIC-funded investments

Since 2017

Investments	167 (30 active)
Total funding	USD 18.2 million
Countries (by USD funded)	China (84%) Brazil (13%) Egypt (1%) Argentina (1%) Georgia (1%) Tunisia (>1%) India (>1%)

Type 2 Investments: Funded by HICs, Led by LMIC-Based Research Organizations

Investments that are made by funders based in HICs and directed at research organizations based in LMICs make up 2% of all investments in animal health AMR R&D and 2% of all funding in this area.⁸ This is the least common of the three LMIC-related investment types included in this analysis, comprising 32 investments worth USD 19.5 million since 2017. Of these, 11 investments remain open. The countries whose funders conduct these investments include the United Kingdom, Canada, the

⁷ Georgia is home to one of the oldest research institutions focusing on bacteriophage research, the Eliava Institute, founded in 1923. For more information, visit the [Eliava Institute Website](#).

⁸ If there are multiple organizations involved in the research, the data considers the investment to be managed by the organization of the project's principal investigator or coordinator.

TYPE 2 FUNDING AT A GLANCE

Investments by HIC funders to research organizations in LMICs

Since 2017

Investments	32 (11 active)
Total funding	USD 19.4 million
Funder countries (by USD funded)	UK (69%) Canada (10%) EU (9%) Sweden (7%) USA (3%) France (3%) Switzerland (>1%)
Research organization regions (by USD funding received)	Sub-Saharan Africa (54%) Asia (32%) North Africa (5%) Americas (9%) Eastern Europe (>1%)

European Union, Sweden, the United States, France and Switzerland. The list of funders in this category is presented in Table 3.

The research organizations to whom this funding is directed are predominantly based in Sub-Saharan Africa (54% of investments), Asia (32%), with the remainder directed at research organizations in North Africa, the Americas and Eastern Europe.

Table 3 List of funders providing type 2 funding for animal health AMR R&D

Funder name	Funder country	Funder type	% of Type 2 funding
Fleming Fund	United Kingdom	Public - Government	52%
Global AMR Innovation Fund (GAMRIF)	United Kingdom	Public - Government	10%
European Commission	European Union	Public - Government	8.6%
International Development Research Centre	Canada	Public - Government	8.5%
Swedish International Development Cooperation Agency	Sweden	Public - Government	6.9%
Wellcome Trust	United Kingdom	Private - Non Profit	4.2%
Bill & Melinda Gates Foundation	United States	Private - Non Profit	3.0%
Agence Nationale de la Recherche	France	Public - Government	2.6%
Global Affairs Canada	Canada	Public - Government	1.5%
Medical Research Council	United Kingdom	Public - Other	1.3%
Academy of Medical Sciences	United Kingdom	Public - Other	0.9%
Swiss National Science Foundation	Switzerland	Public - Government	0.3%

Type 3 Investments: Indirect LMICs' Involvement

The final category of animal health AMR R&D investments considered in this analysis are those funded by an institution in a HIC and directed at a HIC-based research organization, where some component of the research project involves one or more specified LMICs. This is the largest of the three categories of funding involving LMICs in the database, amounting to a total of USD 264 million in funding and 165 investments since 2017. For example, this category includes investments involving multiple research organizations, including some in LMICs, but where the principal investigator is affiliated with a HIC-based institution. Type 3 investments make up 12% of all animal health AMR R&D investments since 2017 and 26% of all funding in this area. The regions with specified LMICs that were linked to these investments include Asia (54% of investments), Sub-Saharan Africa (45%), Oceania (8%), and the Americas (4%).⁹

TYPE 3 FUNDING AT A GLANCE:

Indirect LMIC involvement
Since 2017

Investments	165 (77 active)
Total funding	USD 264 million
Funder countries	United Kingdom (78%) United States (9%) European Union (4%) Japan (3%) Canada (2%) Sweden (1%) Australia (1%) Switzerland (1%) Finland (>1%) Germany (>1%) Norway (>1%) France (>1%) Netherlands (>1%)
Regions of impact (by USD funding)	Asia (54%) Sub-Saharan Africa (45%) Oceania (8%) Americas (4%) North Africa (<1%)

INVESTMENTS BY RESEARCH TYPE, PATHOGEN, AND SECTOR

The goal of this analysis was to determine what type of animal health AMR R&D research is being funded, by whom and in what areas, using currently available data, in order to identify priority funding gaps for LMICs. This analysis draws upon the Global AMR R&D Hub's data on research project investments by research type, pathogen, One Health component and animal subsector. The results of this mapping exercise are presented in this section.

⁹ Some projects may involve LMICs in more than one region; therefore, these percentages are not additive.

Research Type

The scope of the activities included in the Dynamic Dashboard includes (but is not limited to) investments in:

- Product-oriented and product-based R&D for therapeutics, preventives,¹⁰ promotants¹¹ and diagnostics;
- Basic research that improves understanding of a given pathogen, virulence, transmission, impact of external factors and the roles and interaction of different One Health sectors;
- Operational and implementation research;
- Research into new or existing medical interventions;
- Research into quality and/or fake or substandard products;
- Research to inform the development or revisions to policy or regulation;
- Relevant research training, capacity building and network establishment;
- Research on breeding genetic variances targeting AMR; and
- Research that leads to reduced antimicrobial use in general.

These activities are categorized by the components listed in Table 4. A full list of definitions can be found in the Appendix.

Table 4 Animal health AMR R&D research investments involving LMICs by research type since 2017

Includes component	LMIC-related investments	% of all LMIC-related investments	LMIC-related funding (USD, millions)	% of all LMIC-related funding
Operational	183	50%	\$232.2	77%
Basic Research	108	30%	\$16.7	6%
Capacity Building	45	12%	\$129.2	43%
Vaccines	32	9%	\$14.1	5%
Diagnostics	19	5%	\$13.9	5%
Policy	18	5%	\$20.6	7%
Promotants	12	3%	\$6.7	2%
Therapeutics	17	5%	\$11.4	4%
Other Products	9	2%	\$2.4	1%
Preventives (other) ¹²	6	2%	\$3.1	1%

Out of the 364 investments in animal health AMR R&D related to LMICs (types 1, 2 and 3), 50% include an operational component (USD 232 million in total funding), 30% include a basic research component (USD 16.7 million), and 12% include a capacity building component (USD 129 million). The types of

¹⁰ Which includes vaccines and other alternatives to antimicrobials

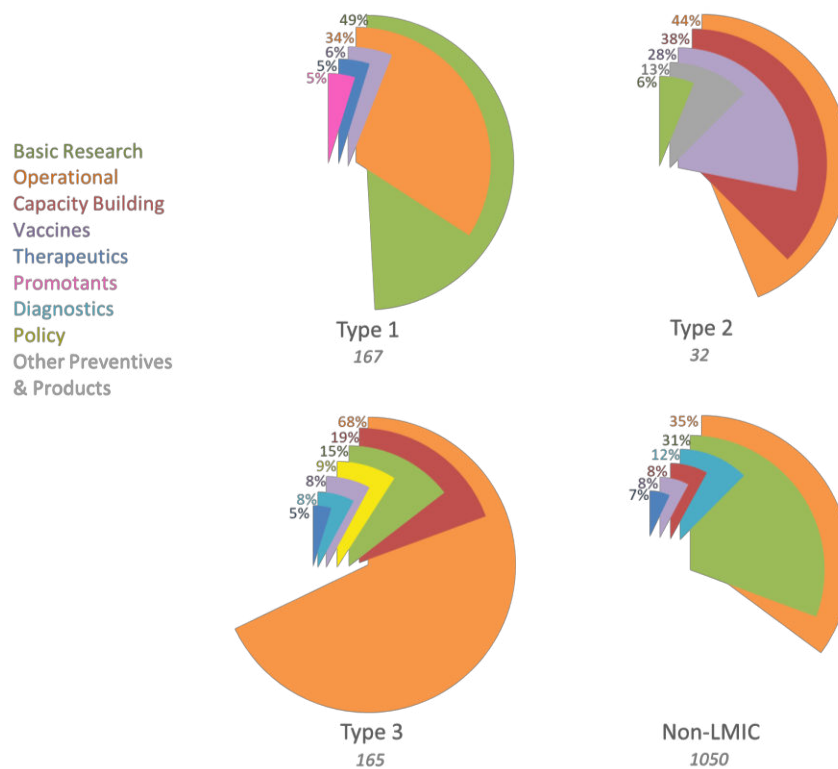
¹¹ Including the promotion of growth and feed efficiency

¹² Excluding vaccines

research investments linked to LMICs that are least funded include promotants (3% of investments and 2% of funding), non-vaccine preventives (i.e., other alternatives to antimicrobials) and other products).

There are some differences in the types of research funded depending on whether the funder is based in an LMIC or HIC, and whether the funds are going to an LMIC research organization or not (see Figure 3). For instance, investments for which the funder and lead research organization are in the same country (whether HIC or a LMIC) are more likely to have basic research as a component (32% of investments in animal health AMR R&D made by same-country funders compared to 20% where the research organization is in another country). Investments made by HIC funders that are LMIC-related (types 2 and 3) are more likely to involve a capacity-building component (38% of investments made by HIC funders with an LMIC research organization, 19% of investments made by HIC funders with an LMIC as a related country), compared to investments by LMIC funders (fewer than 1% of investments). Investments made by HIC funders to an LMIC research institution (type 2) are the most likely to have vaccines and other preventives as a component, compared to other types of LMIC-related investments (28% involves vaccines, 6% involves other preventives). Investments to HICs’ research institutes are most likely to involve diagnostics (8% of HIC-only investments, 8% of type 3 investments, compared with 3% of type 1 and 2 investments).

Figure 3 Share animal health AMR R&D investments by research and investment type since 2017¹³



¹³ The figure shows percentages of 5% or more.

Target Pathogen

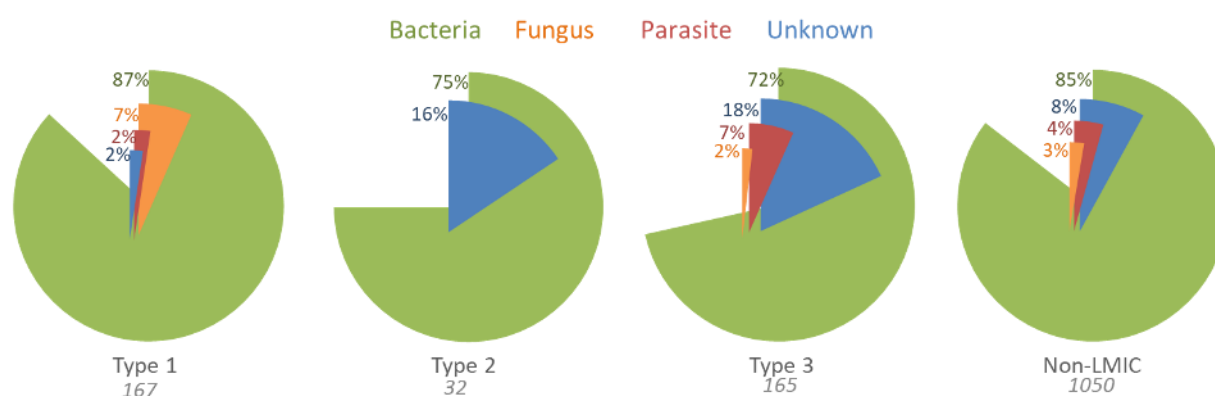
Table 5 Animal health AMR R&D investments involving LMICs by target pathogen category since 2017

Includes	LMIC-related investments since 2017 (types 1-3)	% of all LMIC-related investments	LMIC-related funding since 2017 (USD, millions)	% of all LMIC-related funding
Bacteria	287	79%	\$242	80%
Fungus	14	4%	\$0.68	0%
Parasite	15	4%	\$18	6%
Other	2	1%	\$0.07	0%
Unknown	39	11%	\$33.4	11%

The most common category of target pathogen across all LMIC-related investments are bacteria, which is unsurprising, given that the selection criteria for investment data are primarily focused on bacteria. Seventy-nine percent of all these research investments target either solely bacteria or bacteria along with another type of pathogen. Most of these research investments target one pathogen category (83%), while 4% target two categories, and 1% targets three or more pathogen categories.

There is little difference between investment types in the type of pathogens targeted by investments; the vast majority of all investments across all funding types targets bacterial species (see Figure 4). Investments to HICs' research institutes are more likely to involve parasites as a target pathogen (4% of HIC-only investments, 7% of type 3 funding, compared with under 2% of type 1 and 2 funding).

Figure 4 Share of animal health AMR R&D investments by target pathogen and funding type



Research Sector

Investments in the animal health AMR R&D database can target one or more animal subsectors, in addition to having human, environmental or plant health components. This analysis focuses on investments targeting food animal production—namely livestock (which include cattle and small

ruminants and swine), poultry, and aquaculture (see full definitions in the Appendix: Sub-Categories for the Animal Sector). Investments with both animal and human health components are also considered, as these make up a significant proportion of all investments (see Table 6). Other animal health subsectors included in the database that are not considered in this analysis and represent a small fraction of the investments include companion animals, wildlife, and insects.

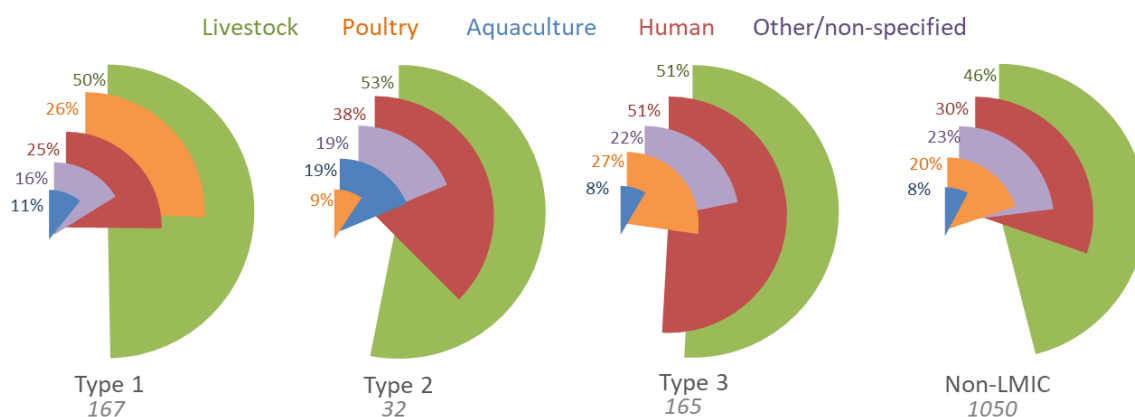
Table 6 Animal health AMR R&D investments involving LMICs by sector since 2017

Includes	LMIC-related investments (types 1-3)	% of all LMIC-related investments	LMIC-related funding (USD, millions)	% of all LMIC-related funding
Livestock	184	51%	\$99.4	33%
Human	138	38%	\$202	67%
Poultry	91	25%	\$95.0	32%
Aquaculture	38	10%	\$36.9	12%
Other or non-specified, excluding the above	69	19%	\$113	37%

Livestock is most often included as a target species in research investments in animal health AMR R&D involving LMICs (51% of these investments have a livestock component). The second most common target species in these research investments is humans, making up 38% of investments. These must also target one or more other animal species, since this subset of the Dynamic Dashboard data only includes investments in projects that have a (non-human) animal component. One quarter of animal health AMR R&D investments involving LMICs target poultry, and 10% have an aquaculture component.

Though livestock is the most common category of animal targeted across all investments in animal health AMR R&D, a greater share of investments made by HIC funders (type 2 and type 3) also target humans (see Figure 5).

Figure 5 Share of animal health AMR R&D investments by sector and by funding type



It is important for AMR research to consider multiple species and systems, given that resistance genes are not constrained to any one species, and that resistant pathogens can emerge from and due to the interactions between human health care settings, animal production systems, plant production systems, water systems, proximity to wildlife, and the environment. The Dynamic Dashboard tracks how many One Health spheres are considered in any given research investment, including human health, animal health, plant health, and environmental health. For LMIC-related investments including an animal health component, 31% include an additional One Health component, and 9% include three components including animal health (Table 7).

Table 7 Animal health AMR R&D investments involving LMICs by One Health component since 2017

Number of One Health components	LMIC-related investments since 2017 (types 1-3)	% of all LMIC-related investments	LMIC-related funding since 2017 (USD, millions)	% of all LMIC-related funding
Animal Only	221	61%	\$97.3	32%
2 sectors	112	31%	\$175	58%
3+ sectors	31	9%	\$29.5	10%

GENDER AND OTHER SOCIOECONOMIC DIMENSIONS

Gender equality and social inclusions are well-recognized priorities in health and development agendas across human and animal health. This extends to the issue of AMR, as biological sex, socially constructed gender, and other socioeconomic factors could potentially affect individuals' and communities' vulnerability to AMR-related risks. This includes factors such as where a person lives, as well as their ability to navigate health care settings, their access to human and animal health services, and the types of professions they occupy, for example.

For instance, in some LMIC country contexts, women predominantly manage the small-scale production of certain types of livestock, but they may also face financial, literacy, mobility or other systemic gender-based barriers to accessing veterinary services for their livestock (Dumas, et al. 2018, Wegaro Obosha 2020). These factors affect knowledge of AMR, and access to and ownership over AMR containment resources (McKune, Serra and Touré 2021).

DEFINITIONS

Sex refers to the biological, physiological, and anatomical differences between men and women, as well as to people with variations in these characteristics (intersex). (Tannenbaum 2016, Korsvik 2020)

Gender is defined as the socially constructed roles, expectations, relationships, behaviours, power relations and other traits that are ascribed to men, women and people of diverse gender identities. (Williams, et al. 2021)

Currently, the Global AMR R&D Hub's Dynamic Dashboard does not include categories for such cross-cutting socioeconomic research themes. A cursory word search of the abstracts revealed that four

included the word “gender” and 13 included the word “women” out of the total of over 1,400 investments in animal health AMR R&D. This indicates that gender, and likely that other social considerations, are rarely an explicit focus of the current research being undertaken in this area. Additional data and analysis would be required to gain a better understanding of the socioeconomic dimensions of animal health AMR R&D investments and potential funding gaps in this area.

DISCUSSION

This analysis of the Dynamic Dashboard data shows indications that the type of research, target pathogens and sectors of research differ depending on whether the funder and/or research institution are based in an LMIC or HIC. These trends, which can be used to inform research funding agendas and address possible funding gaps, are discussed in this section.

There are relatively very few Type 2 investments (HIC-based funder with LMIC-based lead research institution), compared to Type 1 and Type 3. This is a noteworthy gap, as these types of investments enable researchers from LMICs to contribute to global research agendas and advance knowledge in important areas for LMICs. Given that investments made by local funders are more likely to include a basic research component, for instance, this could indicate that there is insufficient basic research on AMR in LMICs that do not have their own active funding institutions, relative to the demand for such research. Furthermore, this type of research funding can help support the situation analysis of local systems required for the development of locally relevant National Action Plans on AMR, as encouraged by the Global Action plan on AMR (Kakkar, et al. 2018).

China and Brazil, along with a few other large middle-income countries, are active contributors to animal health AMR R&D. The difference between Type 1 investments and Type 2 and 3 investments in types of research, target pathogens and animal subsectors could suggest that the priorities of LMICs are not necessarily the same as those of HICs. For instance, target species appears to differ considerably between Type 1 and Type 2 and 3 investments (more investments in the poultry subsector, relatively fewer with a human component). This provides an opportunity for HIC funders to work with countries funding research in animal health AMR as equal partners to share lessons learnt and to avoid duplicative efforts.

Overall, funding in the animal health AMR R&D space is highly concentrated. The UK's public institutions are demonstrating global leadership, making up the bulk of investment dollars in this area. The high concentration of research funding by one country's public sector can present a long-term risk, as AMR is a global issue whose risk is borne by all countries. To continue advancing knowledge and developing solutions for AMR for the animal health sector, it is important for funding to come from multiple sources, thus avoiding vulnerability to changes in the political or economic landscape of a single country.

AMR R&D in the aquaculture sector is relatively underfunded. Only 10% of all LMIC-related investments include aquaculture as a subsector. Aquaculture has grown extremely rapidly in the last 60 years, and there is a much greater diversity of species produced in aquaculture systems than in land-based animal production. The diversity of species and the risks that each type of system represents for AMR, combined with the environmental contamination risks inherent with aquaculture production make aquaculture fertile ground for AMR research, especially in LMICs where aquaculture is an important and growing economic subsector.

There is a need for more research on the gender dimensions of AMR risk in the animal health sector. There are well-studied gender-based differences in livestock rearing, where specific tasks, activities and/or livelihood strategies can be associated with specific gender roles. These vary across regions and cultural contexts, and these gender-based differences can affect certain populations' vulnerabilities to AMR risks. A better understanding of such dimensions could inform the development of better targeted interventions to change behaviour. Cross-cutting socioeconomic dimensions of animal health AMR R&D, like gender, represent a potential funding gap, although more data would be required to assess the size of this gap. To obtain this data, changes in the way information about investments is systematically collected from funders may be required.

CONCLUSIONS

AMR is a human, animal and environmental health problem that transcends national borders. Addressing this problem, consequently, requires significant global cooperation and knowledge sharing. This report uses the publicly available data in the Dynamic Dashboard to analyze investment flows in animal health AMR R&D with a specific focus on LMICs. The patterns and gaps presented in the analysis and elaborated in the discussion are intended to inform international funding agencies and stimulate a wider discussion on priority funding areas for AMR research in LMICs.

The analysis shows that the subset of funders who invest in animal health AMR R&D is highly concentrated in a few countries. Additionally, most of this funding related to low- and middle-income countries does not go directly to research institutions in low- or middle-income countries but rather to those in high-income countries. This presents risks, including that the AMR priorities of LMICs do not receive sufficient funding.

It is important to note that the analysis is constrained by the availability of data. Additional data on investments made by private sector actors and by funders in LMICs is necessary to provide a clearer picture of the global animal health AMR R&D landscape. Those willing to share new data sources for inclusion in the Dynamic Dashboard are encouraged contact the Global AMR R&D Hub.

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APPENDIX

DYNAMIC DASHBOARD CATEGORIES AND DEFINITIONS

The categories and definitions used in this analysis are those used by the Global AMR R&D Hub Dynamic Dashboard ([source](#)). These are intended to be applicable across the different One Health sector.

R&D in Scope

Basic and applied research on AMR that covers all One Health sectors (human, animal, plant and environment). The infectious agents in scope are provided In the Dynamic Dashboard Library.

The activities could include but are not limited to:

- All types of product-oriented and product-based R&D, including research, discovery, development (including field trials), first registration and post registration studies for therapeutics, preventives, promotants and diagnostics
- Basic research that improves understanding of the pathogen, virulence, transmission, impact of external factors and roles and interaction of different One Health sectors and is not necessarily geared towards a specific product, policies or operational processes
- Operational/implementation research such as exploring improvements to surveillance, access to and optimal use of products, epidemiology-related studies, digital products, infection prevention and control and disease management programs
- Research of new or existing medical interventions
- Research into quality and fake or substandard products
- Research to inform policy or regulation development or revision
- Relevant research training (such as support for PhDs & post-docs) and network establishment (capacity building)
- Research on breeding genetic variances targeting AMR
- Research that leads to reduced antibiotic/antimicrobial use (agent not specified)

Exclusion Criteria

Information will not be collected for projects or investments on:

- Research on non-communicable diseases, such as obesity, autoimmune diseases, cancer, allergies, in the context of the use of viral vectors
- R&D on virally caused cancers, reactivated viral infections in immunocompromised individuals such cytomegalovirus or progressive multifocal leukoencephalopathy
- Grants solely for symposia or meetings or travel

- Funding for buildings / capital investments
- Training and professorships where there is not a strong focus on AMR R&D
- Research into insect vector control, biocontrol of insects and insects as pests in general

Research Area

Table 8 Research Area Definitions

Research Area	Definition
Basic Research	<p>Research that addresses fundamental aspects of a concept or phenomenon and aims at increasing scientific knowledge, understanding about the disease, immune response, processes or pathogen but is not yet directed towards a specific product, policies, or operational processes and corresponds to Technology Readiness Levels (TRL) 1-3.</p> <p>This research area includes projects that address both 'fundamental' aspects but also are moving 'towards a product' and could include but are not limited to:</p> <p>Fundamental - no clear path to product development (TLR 1-2)</p> <ul style="list-style-type: none"> • Research into the development and mechanisms of persistence, transmission, virulence, immunology, biology and pathology; genetics (including genetically resistant animals and plants); role of the microbiome in maintenance of health; role of antibiotics in growth promotion; epidemiology and burden; and the interaction between One Health sectors • Fundamental understanding of biological processes or chemistry involved in the synthesis of compounds, including adjuvants and antigens <p>Towards a Product - has the potential to become a product (TLR 3)</p> <ul style="list-style-type: none"> • Search for a potential therapeutic, preventive, promotant or diagnostic target • Early research for the development of imaging or detection technologies/assays • Development of technologies and in silico/in vitro/in vivo models that assist with the design and testing of e.g. drugs and vaccines such as tissue culture and animal models (e.g. mouse models for sepsis, challenge models). • Identification of mode of action of putative new products targeting the pathogen, host and/or the microbiome • "Platform technologies" e.g. for vaccines that broadly refer to a system that uses the same basic components as a backbone, but can be adapted for use against different pathogens by inserting new sequences (which then would become product specific).
Therapeutics <i>Includes therapeutics and treatment</i>	<p>Any product-specific R&D designed for the treatment of infection with an antimicrobial across all product-specific R&D stages such as screening of compounds/antigens, early stages of optimizing a hit or work to better understand a target to post registration studies. This could include but is not limited to:</p> <p>Improvement of current antimicrobials, treatment regimens and therapies</p> <ul style="list-style-type: none"> • Investigation of combination therapies • Dose optimization studies • Investigation of old or off-market antimicrobials for optimization or new targets • Development of new antimicrobials and therapeutic alternatives to 'traditional' antimicrobials, including but not limited to small molecules, natural products, antibodies, vaccines, probiotics and faecal transplant therapy, bacteriophages, antimicrobial peptides, lysins, antitoxins and immune modulators.

	<ul style="list-style-type: none"> • Drug quality (including fake or substandard drugs) and properties such as oral bioavailability, long half-life, etc. that are secondary to activity but can be essential to market viability. • Characterize a target for which some evidence of its usefulness is already available • Combining identification of target and other aspects such as screening/optimizing of compounds <ul style="list-style-type: none"> • In plants, this includes treatment of diseases
Vaccines	<p>Any product-specific R&D designed to prevent systemic disease (no symptoms, could be both sick and healthy subjects).</p> <p>Vaccines are defined as a product (usually a biological preparation or substance) that stimulates the adaptive immune system to develop long-lasting protective immunity against antigens from pathogens and is administered primarily to prevent disease. This is achieved, in general, through the generation of antigen-specific memory T and B cells (adaptive/acquired immune system).</p> <ul style="list-style-type: none"> • Research that addresses challenges in developing vaccines, e.g. identification of protective antigens, defining correlates of protection, understanding most effective antigen delivery methods and stimulating long-term protective immune responses • Identification of vaccine candidate(s): Screening of potential natural or synthetic antigens and other vaccine components (e.g. adjuvants) in a pathogen/disease-specific context and may include e.g. protein/peptide/epitope libraries, antigen-expressing vectors, substances derived from pathogens, weakened pathogens or their toxins, serological activity (neutralizing and non-neutralizing) • Studies conducted to assess vaccine candidate for safety and efficacy (e.g. in tissue culture or cell culture and animal testing and clinical trials).
Preventives – Other	<p>Any product-specific R&D designed to prevent systemic disease (no symptoms, could be both sick and healthy subjects). Preventives – Other are defined as a product (often a drug) that prevents disease through other means than vaccination and by itself does not generate an antigen-specific memory immune response. These are usually introduced into the host by e.g. injection, taken orally or as food/feed as opposed to other products that are applied topically.</p> <ul style="list-style-type: none"> • Prophylactics – medication/treatment to prevent disease from occurring- e.g. administration of antimicrobial with appropriate therapeutic dose for limited and disease appropriate duration in healthy subjects at risk of specific infection or where infection/disease is likely to occur. • Immune modulators – activate, boost or restore normal immune function independent on the pathogen causing infection (not antigen-specific); These include cytokines, lipopolysaccharides, short segments of bacterial DNA that also stimulate innate immune responses (i.e. CpGs), antibodies, and certain plant materials • Trait-selective breeding of animals/plants resistant to AMR infections, e.g. genome editing technologies for the generation of genome editing animals/plants • Other disease prevention products, such as antibiofilm enzymes.
Diagnostics <i>Includes detection, screening and diagnostics</i>	<p>Any product-specific R&D aimed at the development or improvement of detection, screening or diagnosis. This could include but is not limited to:</p> <ul style="list-style-type: none"> • Identification of causative agent (including distinguishing between viral and bacterial) and identification of resistance (including resistance profiles), including susceptibility testing • Development of diagnostic or prognostic tests and devices for clinical use, and use in the field (e.g. animal farm settings)

	<ul style="list-style-type: none"> • Tests and screening tools for population-based, epidemiological studies and surveillance routines aiming at the identification of determinants that are involved in the cause, risk or development of AMR. • Development of companion diagnostics – provide information for the safe and effective use of a corresponding drug or biological product • Development of tests or detection tools including machine learning predictions to identify infected individuals or status of infections with AMR-relevant agent(s) within a herd/flock or environment • Diagnostic tools in support of trait-selective breeding of animals/plants, e.g. genotyping technologies to improve disease resistance (e.g. SNPs).
Promotants	<p>Any product-specific R&D designed to improve or maintain health/welfare and increase productivity and/or growth in the absence of disease/infection. They are usually provided as food/feed additives. This could include but is not limited to:</p> <ul style="list-style-type: none"> • Non-medically important antimicrobials at sub- or non-therapeutic doses used for an ongoing duration • Probiotics - live cultures of microorganisms (e.g. yeast, algae, fungi and bacteria) added to the diet to improve the balance of microbial communities in the gastrointestinal tract. • Prebiotics - organic compounds such as certain sugars that, when added to the diet, are indigestible but are broken down by certain beneficial microorganisms in the gut, which selectively stimulates these and other microorganisms' growth. • Antimicrobial peptides - short molecules with antibacterial properties that are toxic to certain bacteria • Phytochemicals - plant-derived compounds, such as essential oils or tannins that may have antibacterial and growth-promoting effects • Organic acids, enzymes and other alternatives, such as heavy metals (zinc, copper) and clay minerals
Other products	<p>Any product-specific R&D that does not fit under therapeutics, preventives, promotants or diagnostics and are usually for external/topical application. It does not include devices that are part of delivery systems for therapeutics, vaccines or diagnostics. This could include but is not limited to:</p> <ul style="list-style-type: none"> • Biocides - used as antiseptics and disinfectants – chemicals and biological agents used for the expressed purpose to control, deter, inhibit or kill harmful microorganisms. • Biofilm-related products (material, devices, particles, etc.) that prevent, prohibit or interfere with biofilms • Other products like medical devices, wound healing products/dressing, anti-adhesions • Technologies to improve and monitor health, production and welfare in animals such as sensors/devices (via microbiome/weight gain) at individual and herd/flock level (reduction of AMU).
Operational <i>Includes operational and implementation</i>	<p>Operational and implementation research that aids in decision-making and management strategies (at the organizational and local levels) and could include but is not limited to:</p> <ul style="list-style-type: none"> • Infection prevention and control (IPC): Management and interventions aimed at optimizing clinical, veterinary or farming practice related to disinfection, sterilization and disease management programmes (e.g. biosecurity, husbandry methods, use of vaccination, health management) and evidence-based guidelines/policies of IPC programmes • Optimal use / Stewardship: Research and studies to optimize the uptake and use of products (antimicrobials, diagnostics and vaccines and other technologies) with the aim of reducing the emergence or rate of development of resistance and/or the need to consume antibiotics, and

	<p>normally does not impact product-specific label (see registration and implementation). Includes trials which compare agents against each other to inform clinical practice and guideline development</p> <ul style="list-style-type: none"> • Access and Availability: Work that aims to improve the access and availability of AMR- and infection-reducing technologies • Surveillance: Population-level analysis of disease surveillance or monitoring, antimicrobial consumption/usage and resistance trends/development/susceptibility; includes specific informatics tool for collection, management and analysis of AMR testing data • Epidemiology: Studies that analyze determinants of health and disease conditions in defined populations, specifically how, who, when, and where they occur. Major study 28 April 2021 - 4 - areas include disease causation, transmission, outbreak investigation, disease surveillance, environmental epidemiology, occupational epidemiology, screening, biomonitoring, and comparisons of treatment effects such as in clinical trials • Social Science: Research to inform behavioural change among humans (individuals, groups such as farmers, organizations/companies) or in relation to animals, economic analysis to inform and quantify challenges or costs solutions. Impacts of external factors (such as assessments of the contribution of pollution or contamination); the environmental impact of new antimicrobials; digital products • Other: Research that comprises in silico modelling (e.g. for optimization of processes within wastewater treatment plants).
<p>Capacity Building <i>Includes capacity building and infrastructure</i></p>	<p>Efforts aiming to improve the human or infrastructural resource capacity to address the challenges of AMR. May include but is not limited to: laboratory capacity, staff training, network formation (for knowledge sharing only), infrastructural or process improvements for example clinical trial conduct – that goes beyond a single product.</p>
<p>Policy</p>	<p>Research or investments that will inform the development of, review or revision of policies and regulations (national and international). This could include but is not limited to:</p> <ul style="list-style-type: none"> • Relevant research, not listed above, with an objective of informing or proposing concrete changes to policy of influencing stakeholder action in the field of AMR. • Impact of care services such as research into how social factors, financing systems, structures and processes, technologies and behaviours affect access to care, the effectiveness of care, and development and evaluation of interventions to improve services. • Economic impact, cost benefit analysis, economic models and incentives and market analysis • Health technology assessments • Supporting evidence of intervention into national health programmes (economic impact)

Sub-Categories for the Animal Sector

The definitions below include any animal and animal-derived components, such as milk, meat, eggs, fur, leather and wool. Within each animal group, all ages and sexes are included. Animal-derived products for human consumption follow the same categorization and are tagged as 'food' accordingly. Farmed animal groups include livestock, poultry, aquaculture and insects and non-farmed animal groups include companion animals and wildlife.

Table 9 Definitions of animal sector subcategories

Category	Sub-Category	Definition
Livestock	All	Refers to any breed or population of animals kept by humans for a useful, commercial purpose and includes animals raised in an agriculture setting to produce labour and commodities such as meat, milk, fur, leather and wool.
	Cattle	Refers to any cattle (dairy, beef and meat), including cows, bulls, oxen or calves
	Small ruminants	Refers to sheep (<i>Ovis spp</i>) and goats (<i>Capra spp</i>)
	Pig	Refers to domesticated pigs (genus <i>Sus</i>), including terms e.g. Swine, porcine, hogs, porc
	Livestock – Other food	Includes all other domesticated, farmed or captive wild animals (terrestrial) such as bovine (buffalo, bison, yak), Camelidae (camels, llamas, alpacas), Equidae (horses, donkey, mules/hinnies), lagomorphs (hares and rabbits), cervids.
	Livestock – Other-non-food	Refers to all domesticated, farmed or captive wild animals (terrestrial) kept for fur and skin
	Not Specified	Refers to term 'livestock' without additional information regarding the animal group, name or species
Poultry	All	Domesticated or farmed birds, including backyard poultry, kept by humans for their eggs, meat or features
	Chicken	Refers to chicken (<i>Gallus domesticus</i>), including hen, rooster/cock, chicks and terms such as broiler
	Other	Includes e.g. turkey, quail, ostrich, pigeons, ducks, geese
	Not specified	Refers to term 'poultry' without additional information regarding the animal group, name or species
Aquaculture	All	Refers to farming of aquatic animals and implies some form of intervention in the rearing process to enhance production (e.g. Feeding, regular stocking, protection from predators).
	Fish	Refers to any fresh or saltwater species, most common farmed fish are in order carp, salmon, tilapia and catfish
	Other	Includes species within e.g. Crustaceans, mollusca and amphibia and terms such as shellfish
	Not specified	Refers to term 'aquaculture' without additional information regarding the animal group, name or species
Insects		Refers to small hexapod invertebrates within the arthropod phylum and includes domesticated insects such as honeybees (genus <i>Apis</i>) and silkworm
Companion		Refers to animals kept as pets, but can also be in a laboratory and medical/educational set-up and includes e.g. Cats, dogs, ferrets, rodents. It can also include birds and reptiles (except if captured above).
Wildlife		Refers to any feral animal, captive wild animal or wild animal (non-domesticated and non-farmed) that has a phenotype unaffected by human selection and lives independently of direct human supervision or control (exception zoo animals).

Funder Types

In general, public funding is sponsored by a government agency or other publicly recognized organization, whereas private funds are donated mainly through private corporations or philanthropic efforts by a private organization or individual or are invested directly by the private legal entity.

Table 10 Funder types, definitions

Funder Type	Definition
Public – government	Public funding provided at any level of government. This also includes agencies if located within a ministry/department portfolio.
Public – other	<ul style="list-style-type: none"> • Research councils: separate legal entities and politically independent from government (they may still be answerable) • Public universities: state or government owned or receive significant public funds through government
Private – for profit	<ul style="list-style-type: none"> • Pharmaceutical and Biotechnology companies, other relevant entities: entities that research, develop, manufacture, market, distribute, import, offers for sale or sell pharmaceutical products or other products relevant to AMR. • Small and medium-sized enterprises (SME): non-subsidiary, independent firms with fewer than 250 employees and with annual turnover under EUR 50 million / US \$ 55 million.
Private – not for profit	Foundations: independent legal entities set up for charitable purpose and are funded by an endowment, an individual, a family or business (corporation). They are often controlled by an independent board.
Multilateral Organizations	Refers to an alliance of multiple countries pursuing a common goal and deal with issues that are global priorities. Examples include the UN organizations such as WHO, FAO and UNEP and others such as OIE, World Bank, G20, EIB and GAVI
Funding Distributor	In the AMR field funders support organizations that in turn fund external projects or invest in own activities. Both the upstream grants and the downstream investments will be captured. To avoid double-counting, the notion of funding distributor has been introduced in the database. Projects/investments made by a funding distributor are referenced to said funding distributor. This then also allows to trace back the funding flow to where the original investment came from. Examples of such funding distributors are CARB-X and GARDP. The former is a funding organization, the latter a product-development-partnership investing mostly in its own projects. Funding arrangements, where different funders work together through a “virtual pool of funding” are not considered a funding distributor, as the individual funded projects are each recorded only once from the respective funders.

WORLD BANK COUNTRY AND LENDING GROUPS

This analysis uses the June 2020 World Bank Country and Lending Group's classifications to define countries as either high-income (HIC) or low- and middle-income (LMIC). The full list of countries is included in Table 11. LMIC countries include all those listed under low income, lower middle income, and upper-middle income.

Table 11 Countries of the world by region and income group

Country	Region	Income group
Afghanistan	South Asia	Low income
Burkina Faso	Sub-Saharan Africa	Low income
Burundi	Sub-Saharan Africa	Low income
Central African Republic	Sub-Saharan Africa	Low income
Chad	Sub-Saharan Africa	Low income
Congo, Dem. Rep.	Sub-Saharan Africa	Low income
Eritrea	Sub-Saharan Africa	Low income
Ethiopia	Sub-Saharan Africa	Low income
Gambia, The	Sub-Saharan Africa	Low income
Guinea	Sub-Saharan Africa	Low income
Guinea-Bissau	Sub-Saharan Africa	Low income
Haiti	Latin America & Caribbean	Low income
Korea, Dem. People's Rep.	East Asia & Pacific	Low income
Liberia	Sub-Saharan Africa	Low income
Madagascar	Sub-Saharan Africa	Low income
Malawi	Sub-Saharan Africa	Low income
Mali	Sub-Saharan Africa	Low income
Mozambique	Sub-Saharan Africa	Low income
Niger	Sub-Saharan Africa	Low income
Rwanda	Sub-Saharan Africa	Low income
Sierra Leone	Sub-Saharan Africa	Low income
Somalia	Sub-Saharan Africa	Low income
South Sudan	Sub-Saharan Africa	Low income
Sudan	Sub-Saharan Africa	Low income
Syrian Arab Republic	Middle East & North Africa	Low income
Tajikistan	Europe & Central Asia	Low income
Togo	Sub-Saharan Africa	Low income
Uganda	Sub-Saharan Africa	Low income
Yemen, Rep.	Middle East & North Africa	Low income
Algeria	Middle East & North Africa	Lower middle income
Angola	Sub-Saharan Africa	Lower middle income
Bangladesh	South Asia	Lower middle income

Benin	Sub-Saharan Africa	Lower middle income
Bhutan	South Asia	Lower middle income
Bolivia	Latin America & Caribbean	Lower middle income
Cabo Verde	Sub-Saharan Africa	Lower middle income
Cambodia	East Asia & Pacific	Lower middle income
Cameroon	Sub-Saharan Africa	Lower middle income
Comoros	Sub-Saharan Africa	Lower middle income
Congo, Rep.	Sub-Saharan Africa	Lower middle income
Côte d'Ivoire	Sub-Saharan Africa	Lower middle income
Djibouti	Middle East & North Africa	Lower middle income
Egypt, Arab Rep.	Middle East & North Africa	Lower middle income
El Salvador	Latin America & Caribbean	Lower middle income
Eswatini	Sub-Saharan Africa	Lower middle income
Ghana	Sub-Saharan Africa	Lower middle income
Honduras	Latin America & Caribbean	Lower middle income
India	South Asia	Lower middle income
Kenya	Sub-Saharan Africa	Lower middle income
Kiribati	East Asia & Pacific	Lower middle income
Kyrgyz Republic	Europe & Central Asia	Lower middle income
Lao PDR	East Asia & Pacific	Lower middle income
Lesotho	Sub-Saharan Africa	Lower middle income
Mauritania	Sub-Saharan Africa	Lower middle income
Micronesia, Fed. Sts.	East Asia & Pacific	Lower middle income
Moldova	Europe & Central Asia	Lower middle income
Mongolia	East Asia & Pacific	Lower middle income
Morocco	Middle East & North Africa	Lower middle income
Myanmar	East Asia & Pacific	Lower middle income
Nepal	South Asia	Lower middle income
Nicaragua	Latin America & Caribbean	Lower middle income
Nigeria	Sub-Saharan Africa	Lower middle income
Pakistan	South Asia	Lower middle income
Papua New Guinea	East Asia & Pacific	Lower middle income
Philippines	East Asia & Pacific	Lower middle income
São Tomé and Príncipe	Sub-Saharan Africa	Lower middle income
Senegal	Sub-Saharan Africa	Lower middle income
Solomon Islands	East Asia & Pacific	Lower middle income
Sri Lanka	South Asia	Lower middle income
Tanzania	Sub-Saharan Africa	Lower middle income
Timor-Leste	East Asia & Pacific	Lower middle income
Tunisia	Middle East & North Africa	Lower middle income

Ukraine	Europe & Central Asia	Lower middle income
Uzbekistan	Europe & Central Asia	Lower middle income
Vanuatu	East Asia & Pacific	Lower middle income
Vietnam	East Asia & Pacific	Lower middle income
West Bank and Gaza	Middle East & North Africa	Lower middle income
Zambia	Sub-Saharan Africa	Lower middle income
Zimbabwe	Sub-Saharan Africa	Lower middle income
Albania	Europe & Central Asia	Upper middle income
American Samoa	East Asia & Pacific	Upper middle income
Argentina	Latin America & Caribbean	Upper middle income
Armenia	Europe & Central Asia	Upper middle income
Azerbaijan	Europe & Central Asia	Upper middle income
Belarus	Europe & Central Asia	Upper middle income
Belize	Latin America & Caribbean	Upper middle income
Bosnia and Herzegovina	Europe & Central Asia	Upper middle income
Botswana	Sub-Saharan Africa	Upper middle income
Brazil	Latin America & Caribbean	Upper middle income
Bulgaria	Europe & Central Asia	Upper middle income
China	East Asia & Pacific	Upper middle income
Colombia	Latin America & Caribbean	Upper middle income
Costa Rica	Latin America & Caribbean	Upper middle income
Cuba	Latin America & Caribbean	Upper middle income
Dominica	Latin America & Caribbean	Upper middle income
Dominican Republic	Latin America & Caribbean	Upper middle income
Ecuador	Latin America & Caribbean	Upper middle income
Equatorial Guinea	Sub-Saharan Africa	Upper middle income
Fiji	East Asia & Pacific	Upper middle income
Gabon	Sub-Saharan Africa	Upper middle income
Georgia	Europe & Central Asia	Upper middle income
Grenada	Latin America & Caribbean	Upper middle income
Guatemala	Latin America & Caribbean	Upper middle income
Guyana	Latin America & Caribbean	Upper middle income
Indonesia	East Asia & Pacific	Upper middle income
Iran, Islamic Rep.	Middle East & North Africa	Upper middle income
Iraq	Middle East & North Africa	Upper middle income
Jamaica	Latin America & Caribbean	Upper middle income
Jordan	Middle East & North Africa	Upper middle income
Kazakhstan	Europe & Central Asia	Upper middle income
Kosovo	Europe & Central Asia	Upper middle income
Lebanon	Middle East & North Africa	Upper middle income

Libya	Middle East & North Africa	Upper middle income
Malaysia	East Asia & Pacific	Upper middle income
Maldives	South Asia	Upper middle income
Marshall Islands	East Asia & Pacific	Upper middle income
Mexico	Latin America & Caribbean	Upper middle income
Montenegro	Europe & Central Asia	Upper middle income
Namibia	Sub-Saharan Africa	Upper middle income
North Macedonia	Europe & Central Asia	Upper middle income
Paraguay	Latin America & Caribbean	Upper middle income
Peru	Latin America & Caribbean	Upper middle income
Russian Federation	Europe & Central Asia	Upper middle income
Samoa	East Asia & Pacific	Upper middle income
Serbia	Europe & Central Asia	Upper middle income
South Africa	Sub-Saharan Africa	Upper middle income
St. Lucia	Latin America & Caribbean	Upper middle income
St. Vincent and the Grenadines	Latin America & Caribbean	Upper middle income
Suriname	Latin America & Caribbean	Upper middle income
Thailand	East Asia & Pacific	Upper middle income
Tonga	East Asia & Pacific	Upper middle income
Turkey	Europe & Central Asia	Upper middle income
Turkmenistan	Europe & Central Asia	Upper middle income
Tuvalu	East Asia & Pacific	Upper middle income
Venezuela, RB	Latin America & Caribbean	Upper middle income
Andorra	Europe & Central Asia	High income
Antigua and Barbuda	Latin America & Caribbean	High income
Aruba	Latin America & Caribbean	High income
Australia	East Asia & Pacific	High income
Austria	Europe & Central Asia	High income
Bahamas, The	Latin America & Caribbean	High income
Bahrain	Middle East & North Africa	High income
Barbados	Latin America & Caribbean	High income
Belgium	Europe & Central Asia	High income
Bermuda	North America	High income
British Virgin Islands	Latin America & Caribbean	High income
Brunei Darussalam	East Asia & Pacific	High income
Canada	North America	High income
Cayman Islands	Latin America & Caribbean	High income
Channel Islands	Europe & Central Asia	High income
Chile	Latin America & Caribbean	High income
Croatia	Europe & Central Asia	High income

Curaçao	Latin America & Caribbean	High income
Cyprus	Europe & Central Asia	High income
Czech Republic	Europe & Central Asia	High income
Denmark	Europe & Central Asia	High income
Estonia	Europe & Central Asia	High income
Faroe Islands	Europe & Central Asia	High income
Finland	Europe & Central Asia	High income
France	Europe & Central Asia	High income
French Polynesia	East Asia & Pacific	High income
Germany	Europe & Central Asia	High income
Gibraltar	Europe & Central Asia	High income
Greece	Europe & Central Asia	High income
Greenland	Europe & Central Asia	High income
Guam	East Asia & Pacific	High income
Hong Kong SAR, China	East Asia & Pacific	High income
Hungary	Europe & Central Asia	High income
Iceland	Europe & Central Asia	High income
Ireland	Europe & Central Asia	High income
Isle of Man	Europe & Central Asia	High income
Israel	Middle East & North Africa	High income
Italy	Europe & Central Asia	High income
Japan	East Asia & Pacific	High income
Korea, Rep.	East Asia & Pacific	High income
Kuwait	Middle East & North Africa	High income
Latvia	Europe & Central Asia	High income
Liechtenstein	Europe & Central Asia	High income
Lithuania	Europe & Central Asia	High income
Luxembourg	Europe & Central Asia	High income
Macao SAR, China	East Asia & Pacific	High income
Malta	Middle East & North Africa	High income
Mauritius	Sub-Saharan Africa	High income
Monaco	Europe & Central Asia	High income
Nauru	East Asia & Pacific	High income
Netherlands	Europe & Central Asia	High income
New Caledonia	East Asia & Pacific	High income
New Zealand	East Asia & Pacific	High income
Northern Mariana Islands	East Asia & Pacific	High income
Norway	Europe & Central Asia	High income
Oman	Middle East & North Africa	High income
Palau	East Asia & Pacific	High income

Panama	Latin America & Caribbean	High income
Poland	Europe & Central Asia	High income
Portugal	Europe & Central Asia	High income
Puerto Rico	Latin America & Caribbean	High income
Qatar	Middle East & North Africa	High income
Romania	Europe & Central Asia	High income
San Marino	Europe & Central Asia	High income
Saudi Arabia	Middle East & North Africa	High income
Seychelles	Sub-Saharan Africa	High income
Singapore	East Asia & Pacific	High income
Slovak Republic	Europe & Central Asia	High income
Slovenia	Europe & Central Asia	High income
Spain	Europe & Central Asia	High income
St. Kitts and Nevis	Latin America & Caribbean	High income
Sweden	Europe & Central Asia	High income
Switzerland	Europe & Central Asia	High income
Taiwan, China	East Asia & Pacific	High income
Trinidad and Tobago	Latin America & Caribbean	High income
Turks and Caicos Islands	Latin America & Caribbean	High income
United Arab Emirates	Middle East & North Africa	High income
United Kingdom	Europe & Central Asia	High income
United States	North America	High income
Uruguay	Latin America & Caribbean	High income