Acknowledgments

The Global AMR R&D Hub would like to extend its thanks to all the individuals, globally, who have generously provided their input, expertise and time to help support the development and optimisation of the Dynamic Dashboard.

Special thanks to the funders who have provided their data, the Global AMR R&D Hub’s Board of Members and Stakeholder Group, and both current and former members of the Global AMR R&D Secretariat for all their support.

The Global AMR R&D Hub receives funding from the German Federal Ministry of Education and Research (BMBF, #01KA1810) & the German Federal Ministry of Health (BMG, #ZMVI1-2519GHP714).

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To cite the report, please use the following: Global AMR R&D Hub (2021). Annual Report 2021: The Global AMR R&D Funding Landscape.

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Preface

The mandate of the Global Antimicrobial Resistance Research and Development Hub (Global AMR R&D Hub or the Hub) has three important pillars, namely, to guide and support evidence-based decision making, to enhance collaboration and to promote awareness and visibility of AMR. Since its inception, the Hub has endeavoured to advocate for AMR R&D, adoption and access through a One Health lens.

Data and evidence generation are integral to informing effective policy decisions. The derivation of meaningful information is a key element in the decision-making process. In this regard, the Hub’s Dynamic Dashboard plays an important role in both identifying the dynamics of AMR R&D funding globally as well as the existing gaps in R&D that urgently require solutions.

The Dynamic Dashboard has evolved and became truly One Health in April 2021 with incorporation of animal, plant and environmental projects. In the previous analysis that we published in November 2020, the Dynamic Dashboard had 7496 projects and 141 funders with cumulative funding of 5.6 billion USD. In September 2021, the database has significantly increased its depth and breadth and now tracks more than 12,000 projects and 214 funders spread across 46 countries plus the European Union with a combined investment of 8.91 billion dollars (US).

While we appreciate that gaps exist in the database, we believe that the Dynamic Dashboard and the resulting in-depth analyses of the data therein provides a robust knowledge foundation and unique perspective for policy and decision makers.

This year’s analysis would not have been possible without the untiring efforts by the team at the Hub Secretariat – Lesley Ogilvie, Ralf Sudbrak and Usha Lamichhane – who have diligently looked into every aspect of the Dynamic Dashboard and extracted meaningful insights.

As we look into the future, we hope to strengthen the Dynamic Dashboard and incorporate more relevant data and information from our members and stakeholders whose support is critical to us. We believe that the insights gained from this in-depth analysis of the Dynamic Dashboard data will spur collective action in alleviating the challenge posed by the “silent pandemic” of AMR.
# Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMR</td>
<td>Antimicrobial resistance</td>
</tr>
<tr>
<td>BMGF</td>
<td>Bill &amp; Melinda Gates Foundation</td>
</tr>
<tr>
<td>CARB-X</td>
<td>Combating Antibiotic-Resistant Bacteria Biopharmaceutical Accelerator</td>
</tr>
<tr>
<td>CDC</td>
<td>Centre for Disease Control</td>
</tr>
<tr>
<td>GARDP</td>
<td>Global Antibiotic Research and Development Partnership</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>PASTEUR</td>
<td>The Pioneering Antimicrobial Subscriptions to End Upsurging Resistance Act</td>
</tr>
<tr>
<td>PEW</td>
<td>The Pew Charitable Trusts</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and development</td>
</tr>
<tr>
<td>USD</td>
<td>United States dollar</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organisation</td>
</tr>
</tbody>
</table>
Executive Summary

Antimicrobial Resistance (AMR) continues to be a major global health challenge with impacts across the full One Health spectrum – human, animal, plant and environment. Tackling the multi-faceted challenge of AMR requires a concerted global effort to fill gaps in the current knowledge and evidence base, to maximise existing resources and identify the most appropriate areas for further investment.

The Global AMR Research and Development (R&D) Hub’s Dynamic Dashboard – a platform that continuously collects and presents information on global investments in AMR R&D – now in its second year - provides a global snapshot of AMR R&D activities across the full One Health spectrum, offering an evidence base to foster global priority setting and decision making on the allocation of resources.

In this second Annual Analysis of the Dynamic Dashboard data – the first to include projects from all One Health sectors (& human fungal pathogens) – we aimed to provide a consolidated overview of the global AMR R&D funding landscape as at 1st September 2021. Only projects that were active on 1st January 2017 or that started after this date are included in the Dynamic Dashboard.

In doing so, we detail what type of AMR R&D is being conducted by whom and where, in order to identify gaps, opportunities, overlaps and potential for cross-sectoral collaboration.

Currently, the Dynamic Dashboard presents information across three galleries:

- **Investment Gallery**: Showing investments in AMR R&D globally from public and philanthropic sources.

- **Clinical Pipeline Gallery**: Offering a consolidated overview of the clinical pipeline of human antibacterials in development.

- **Incentives Gallery**: Collates the activities occurring along the value chain that try to support the therapeutic development ecosystem and mitigate some of the well-known challenges hindering their development, uptake and distribution.
KEY FINDINGS

Investment Gallery

Key insights from analysis of the Investment Gallery are as follows:

- As at 1st September 2021, a total of 12,093 projects from 214 funders with a total investment of 8.91 billion United States dollars (USD) were presented within the Dynamic Dashboard. Geographical coverage across all continents has been achieved, with investments being made to organisations across 86 countries, from 214 funders (public & philanthropic) originating in 46 countries plus the European Union (EU).

- There has been a steady increase in public and philanthropic investment in AMR R&D from 2017-2019, with an increase from 1.65 billion USD in 2017 to 1.8 billion USD in 2019. As more data is integrated into the Dynamic Dashboard, the trajectory for 2020 and 2021 will become clearer, including any potential impact of Covid-19 on the funding landscape.

- Globally, the majority of investments (90%) are directed towards R&D targeting bacterial pathogens.

- Investment in human health related AMR R&D dominates the landscape, capturing 86% of the funding volume (7.71 billion USD, n=10,035)\(^1\), with Basic Research and Therapeutics key focus areas.

- When looking at human sector only projects (7.49 billion USD, n=9482)\(^2\), over half (58%, 4.4 billion USD) target priority bacterial pathogens. Mapping of this funding according to priority level shows that close to half (45%, 2.91 billion USD) is directed toward High priority bacteria\(^3\).

- Taken collectively, the top 3 research areas in terms of funding volume across all sectors are Basic Research, Therapeutics and Operational R&D, with investment in product-related R&D such as Diagnostics and Vaccines lagging behind Therapeutics. However, the emphasis on specific research areas differs according to One Health sector.

- There is an emerging One Health focus within AMR R&D – i.e., cross sectoral research – comprising 5% of all projects and capturing 6% (533 million USD) of the total investment captured within the Dynamic Dashboard.

---

\(^1\) These values include single sector projects plus the human health fraction of cross-sectoral projects.

\(^2\) These values include only single sector human health projects

\(^3\) See Section 8.3 for list of priority bacteria
- Farmed animals remain a key focus for animal health AMR R&D, with livestock-associated projects accounting for close to half (41%, 309 million USD) of the funding directed towards the animal health sector (757 million USD). Operational research is a major focus in animal health R&D. In the context of product-related research, the emphasis is placed on Vaccines and Diagnostics.

- The plant and environmental health sectors are represented for the first time within the Dynamic Dashboard, albeit both representing only ~1% and 2% of the total funding volume, respectively (Plant = 78 million USD, Environment = 182 million USD). Within the plant health sector, a stronger focus is placed on Prevention R&D, whereas Operational R&D is at the forefront for the environmental health sector. Notably, there is an emphasis on cross sectoral projects within the environmental health sector (51%, 93 million USD).

**Clinical Pipeline Gallery**

This gallery combines analysis from the World Health Organisation (WHO) [1] and the PEW Charitable Trusts [2,3] on the current state of the global pipeline of antibacterials in clinical development. The collation of these data into the Dynamic Dashboard enables a more consolidated view of the clinical pipeline. Of the 104 products in the pipeline, more than two thirds (68%) are traditional antibacterial agents (e.g., small molecule antibiotics) and one third (32%) are non-traditional agents (e.g., bacteriophages, antibodies, immunomodulating agents and microbiome-modulating agents), with the majority (70%) of products still in the early stages of clinical development (Phase 1 or 2). Innovation in the pipeline remains limited, with less than a quarter (21%) of traditional products representing a new class and having a new target.

**Incentives Gallery**

The Incentives Gallery captures, displays and tracks on an interactive page, incentives being implemented globally that aim to improve the functioning of markets – and the broader R&D ecosystem – responsible for the development and distribution of therapeutics for the treatment of priority human bacterial infections. Insight into the scale of investment within the pre-approval stages shows a broad funding landscape (89 funders located within 53 countries + EU) but one that is dominated by a small number of large-scale funders.

A qualitative overview of the pull support to overcome some of the economic challenges in therapeutic markets following approval shows that the
landscape remains ad hoc, small-scale and initiated by just a few countries globally. New initiatives in pilot phase or in development are included within the Gallery, including the UK’s and Sweden’s reimbursement pilots, Germany’s reimbursement incentive for antibiotics (Act on Fair Competition among the Statutory Health Insurance Funds (GKV-FKG)⁴ that would allow higher prices for antibiotics to be charged, as well as legislation proposed in the US (The Pioneering Antimicrobial Subscriptions to End Upsurging Resistance – PASTEUR ACT) that would allow guaranteed minimal annual revenues for antibiotics.

Further work in the priority signalling arena, especially by the WHO, will see a new priority list for fungal pathogens in the near future.

Conclusion

The Dynamic Dashboard now offers a robust knowledge foundation that can be leveraged to identify gaps and opportunities, not only for funding and policy decisions but also in support of partnerships and collaborations across sectors. The outcomes and resulting analysis will help to inform progress across the sector. The Dynamic Dashboard will continue to mature and evolve as its depth and breadth is expanded.

Notably, the insights gained here are constrained by the underlying data captured by the Dynamic Dashboard, which is still limited in its scope.

Additional data from a greater coverage of geographies, as well as information on investments made by the private sector, is required to provide a more comprehensive picture of the global AMR R&D funding landscape.

⁴ Reserve antibiotics active against multi-resistant bacteria gain orphan-like status in the health technology assessment procedure in Germany to incentivise their development and marketing
Investments in human, animal, plant and environment-health related AMR R&D
Investments since January 2017 from public and philanthropic funders

Investments in AMR R&D:
- 12,093 projects
- 214 funders
- 8.91bn USD

Geographical coverage of investments:
- 46 countries + EU - funders
- International funding = 46%
- Received by ROs in 86 countries

Majority of funding directed towards:
- Human health: 86%
- Basic research: 28%
- Therapeutics: 23%
Pipeline of human antibacterials in clinical development

- Of the 104 products in the pipeline, the majority are focused on priority pathogens but are still in the early stages of clinical development (Phase 1 or 2).
- Innovation in the pipeline remains limited, with less than a quarter of traditional products representing a new class and having a new target.

Incentives for antibacterial R&D

- At pre-approval stages the funding landscape is dominated by a small number of large-scale funders.
- Beyond approval support to overcome some of the economic challenges in therapeutic markets remains ad hoc, small-scale and initiated by just a few countries globally.

Conclusions & next steps

- A truly One Health global snapshot of the state of AMR R&D funding from 2017–2021.
- A robust knowledge foundation to identify gaps and opportunities in AMR R&D - for funding & policy decisions and in support of partnerships & collaborations across sectors.
- The Dynamic Dashboard will continue to mature and evolve, expanding its depth and breadth across all One Health sectors.
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1. Introduction

Antimicrobial resistance (AMR) represents a serious and growing threat worldwide. The number of infectious agents and, in particular, bacterial pathogens that have developed resistance to antimicrobials is increasing. Given the urgency of the situation there is a need for coordinated efforts in AMR research and development (R&D). Identifying duplication, recognising and building on existing activities and highlighting gaps and opportunities will help to ensure the most efficient use of efforts and resources.

The Global AMR R&D Hub was established following a call from G20 leaders for a new international R&D collaboration hub to “maximise the impact of existing and new antimicrobial basic and clinical research initiatives as well as product development” [4]. Through the development of the Dynamic Dashboard [5], the Global AMR R&D Hub presents the global landscape of AMR R&D in three ‘galleries’: investments in AMR R&D (Investment Gallery), the pipeline of antibacterials in clinical development (Pipeline Gallery) and incentives for antibacterial R&D (Incentives Gallery).

Since its inception, the goal of the Dynamic Dashboard has been collecting and presenting information on AMR R&D investments, products in the pipeline and push and pull incentives across these three galleries. Currently, the Dynamic Dashboard presents basic and applied research projects/investments from publicly and philanthropically funded R&D throughout the research and innovation value chain on treatment, preventive measures, diagnostic products, surveillance, policy and interventions (such as stewardship) across One Health sectors.

In the intervening period between the publication of our 1st Annual Report in November 2020 [6] and now, the Dynamic Dashboard has been steadily increasing its depth and breadth, with integration of investments across the full One Health spectrum (human, animal, plant and environment) and encompassing a broader range of infectious agents.

Key updates to the Investment Gallery include the inclusion of R&D investments for human fungal pathogens (January 2021) [7], the addition of plant and environmental health projects (April 2021) [8], as well as a ‘Funding Distributor’ Report outlining information on what funds are flowing into the Global Antibiotic Research and Development Partnership (GARDP) and the Combating Antibiotic-Resistant Bacteria...
Biopharmaceutical Accelerator (CARB-X) [9] and the distribution of these funds to organisations and partnerships supported by them. In addition, we have integrated the latest reports and data (latest update April 2021) from the World Health Organisation (WHO) [1] and the PEW Charitable Trusts (PEW) [2, 3] on the current state of the global pipeline of antibacterials in clinical development, and improved the functionality and user-friendliness of the Incentives Gallery [10].

Here, we provide a consolidated overview of the global AMR R&D funding landscape as at 1st September 2021. The aim of this analysis is to determine what type of AMR R&D research is being conducted by whom in what areas, in order to identify gaps, opportunities, overlaps and potential for cross-sectoral collaboration.
2. Results

2.1 Investment Gallery

The Investment Gallery of the Dynamic Dashboard presents public and philanthropic investments in AMR R&D\(^5\) (Dashboard link). At the cut-off date of 1st September 2021, the Investment Gallery presented information on 12,093 projects within research organisations in 86 countries (all continents), worth 8.91 billion United States dollars (USD) from 214 different funders and spanning all 4 One Health sectors (human, animal, plant, environment).

---

\(^5\) Only projects that were active on or started on/after 1st January 2017 are included in the Investment Gallery
2.1.1 Maturation & Evolution of the Dynamic Dashboard

At launch in March 2020, the Investment Gallery included 4,976 human drug-resistant bacterial projects from 81 different funders with a total of $2.9 billion USD provided to research organisations in 53 countries. Since then, the Dynamic Dashboard has progressively expanded its depth and breadth, continuing to add more AMR-relevant projects, funders, research organisations and countries (Figure 1), as well as including R&D investments in animal health (July 2020), human fungal pathogens (January 2021), and plant and environmental health projects (April 2021).

As at 1st September 2021, the Dynamic Dashboard presented information on a total of 12,093 projects worth 8.91 billion USD, spanning 4 One Health sectors. This funding, originating from 214 funders (public and philanthropic) from 46 countries, plus the European Union (EU), is distributed across research organisations based in 86 countries. (See Figure 1).

![Figure 1: Expansion of the Dynamic Dashboard from March 2020 to August 2021. The bars represent the number and amount of investments (left-hand scale), the lines indicate the number of funders (red line) and countries of Research Organisations (RO, green line) (right-hand scale).]
With the expansion of the number of projects deposited with the Dynamic Dashboard (an increase of 288% in the sum of investments since March 2020), there is also the potential to provide more insight into the evolution of funding over time and identify any trends.

When evaluating the change in funding per year as aggregated funding amounts (Figure 2), an increase in spending on AMR-related R&D was noted in 2018 and 2019 as compared to 2017 (overall increase of 9% and 8%, respectively). In 2020, a 22% decrease in funding volume (as compared to 2019) was measured, but this is likely to reflect the time lines associated with reporting investments by the various funding organisations as well as the inclusion of available data into the Dynamic Dashboard.

Next, the funding volume and project numbers according to the project start year were analysed, enabling delineation of any emerging trends in funding across time (Figure 3). In doing so, a downward trajectory becomes apparent across 2017–2020, with a gradual decline in numbers of projects and investments being made moving from 2017 to 2019 (5% decrease in funding and project numbers), which becomes more evident by 2020 (38% decrease in funding amount). However, again the caveat regarding the time line with regards to integrating projects within the Dynamic Dashboard remains regarding data from 2020.

\[\text{Figure 2: Aggregated investments (million USD) and number of projects by year (2017-2020).}\]

\[\text{6 Due to the time lines associated with reporting investments by funding organisations plus the time required to integrate data into the Dynamic Dashboard, the data for 2020 are likely to be incomplete, therefore conclusions on the funding trajectory cannot be made for this time period.}\]
This apparent slight downward trend needs to be placed in the context of the variation in availability of data across the funding organisations. To normalise for inconsistencies in data availability across the years, we identified funders for which more comprehensive data was available across the full 2017−2020 period. A total of 73 funders were identified (from the 214 funders in the Dynamic Dashboard) and the funding trends re-examined in terms of number of projects and investments, allowing a more cohesive overview. This analysis shows that while numbers of projects decrease marginally across 2017−2019 (1658 to 1588), investments increase from 1.2 to close to 1.3 billion USD, providing a more accurate snapshot of the emerging trends in the AMR R&D funding landscape (Figure 4).
2.1.2 What type of AMR R&D is being funded?

In April 2021, the Dynamic Dashboard became truly One Health, with the inclusion of projects addressing plant and environmental health.

Figure 5 and Table 1 provide an overview of these investments across all sectors (including single and cross-sectoral projects as well as those projects in which the sector was categorised as ‘not specified’).

The percentage of funding per sector is shown in Figure 5, with human health-associated projects receiving the majority of funding (84%, 7499 million USD), followed by animal (6%, 552 million USD), plant (1%, 58 million USD) and environmental (1%, 89 million USD) projects. (Values are based on single-sector projects only and do not include any cross-sectoral7 contribution).

As outlined in Table 1, 555 projects are also categorised as ‘not specified’ and cannot be assigned to a specific sector. These projects represent 2% (180 million USD) of the total funding volume. Cross-sectoral projects comprise 5% (n=641) of all projects, capturing 6% (533 million USD) of the total funding.

The lower number of projects in the plant and environmental health sectors also reflect that they have only recently been integrated within the Dynamic Dashboard (April 2021). However, the overall distribution of funding is anticipated to remain largely unchanged with the majority flowing to human health-related R&D.

---

7 Cross-sectoral: spanning more than one sector – human, animal, plant, environment
Table 1 also indicates whether projects were assigned to one or more of the nine defined research areas\(^8\) [11]. Overall, projects spanning more than one research area represent 6% (n=736) of projects and 16% (1434 million USD) of the investments made.

Figure 6 & Table 2 provide a more detailed breakdown per research area in terms of number of projects, investment (USD) and corresponding percentages. The majority of the total investment provided by the 214 funders captured by the Dynamic Dashboard supports projects covering Basic Research (28%), Therapeutics (23%) and Operational (& Implementation) research (20%)\(^9\).

*Human health-associated projects receive the majority of R&D funding, followed by animal, plant and environmental projects*

\(^8\) Definitions for each research area can be found at: Categories and Definitions Investments\([11]\)

\(^9\) Percentages calculated based on single sector projects only.
<table>
<thead>
<tr>
<th>Sector</th>
<th>Projects single research area</th>
<th>Projects multiple research areas</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Investment (million USD)</td>
<td>Number of projects</td>
<td>Investment (million USD)</td>
</tr>
<tr>
<td>Animal</td>
<td>376</td>
<td>774</td>
<td>176</td>
</tr>
<tr>
<td>Environment</td>
<td>85</td>
<td>319</td>
<td>4</td>
</tr>
<tr>
<td>Human</td>
<td>6,456</td>
<td>8,993</td>
<td>1,042</td>
</tr>
<tr>
<td>Plant</td>
<td>51</td>
<td>168</td>
<td>8</td>
</tr>
<tr>
<td>Cross sector</td>
<td>335</td>
<td>554</td>
<td>198</td>
</tr>
<tr>
<td>Not specified</td>
<td>174</td>
<td>549</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>7,477</td>
<td>11,357</td>
<td>1,434</td>
</tr>
</tbody>
</table>

Table 1: Number of projects by One Health Sector and research area (Projects are grouped according to single or multiple research areas). *Totals do not match due to rounding of values. Totals for each specific sector only include values for projects that have a single sector focus.

![Bar chart](chart.png)

Figure 6: Total investments (million USD) captured in the Dynamic Dashboard as per research area.
<table>
<thead>
<tr>
<th>Research Area*</th>
<th>No of projects</th>
<th>% share of number of projects</th>
<th>Investment (USD)</th>
<th>% of investment</th>
<th>Median investment per project (USD)</th>
<th>Mean investment per project (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Research</td>
<td>6,150</td>
<td>47.7</td>
<td>2,534,809,570</td>
<td>28.4</td>
<td>176,585</td>
<td>412,164</td>
</tr>
<tr>
<td>Therapeutics</td>
<td>1,423</td>
<td>11.0</td>
<td>2,024,692,592</td>
<td>22.7</td>
<td>301,241</td>
<td>1,422,834</td>
</tr>
<tr>
<td>Operational</td>
<td>2,615</td>
<td>20.3</td>
<td>1,807,412,211</td>
<td>20.3</td>
<td>217,706</td>
<td>691,171</td>
</tr>
<tr>
<td>Capacity building</td>
<td>517</td>
<td>4.0</td>
<td>780,558,469</td>
<td>8.8</td>
<td>262,550</td>
<td>1,509,784</td>
</tr>
<tr>
<td>Vaccines</td>
<td>418</td>
<td>3.2</td>
<td>656,605,222</td>
<td>7.4</td>
<td>272,655</td>
<td>1,570,826</td>
</tr>
<tr>
<td>Diagnostics</td>
<td>882</td>
<td>6.8</td>
<td>654,380,958</td>
<td>7.3</td>
<td>236,238</td>
<td>741,929</td>
</tr>
<tr>
<td>Other products</td>
<td>575</td>
<td>4.5</td>
<td>232,229,880</td>
<td>2.6</td>
<td>167,900</td>
<td>403,878</td>
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<tr>
<td>Preventives</td>
<td>132</td>
<td>1.0</td>
<td>93,136,512</td>
<td>1.0</td>
<td>186,935</td>
<td>705,580</td>
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<tr>
<td>Policy</td>
<td>145</td>
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<td>81,977,457</td>
<td>0.9</td>
<td>173,311</td>
<td>565,362</td>
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<tr>
<td>Promotants</td>
<td>49</td>
<td>0.4</td>
<td>46,077,296</td>
<td>0.5</td>
<td>329,819</td>
<td>940,353</td>
</tr>
<tr>
<td>Total</td>
<td>12,093*</td>
<td></td>
<td>8,911,880,168</td>
<td></td>
<td>223,385</td>
<td>736,945</td>
</tr>
</tbody>
</table>

Table 2: Investments by research area. Mean and median figures are provided to show the range of funding per project. *Projects can be categorised in more than one research area. The investments were split accordingly, but not the number of projects. Therefore, double counting of projects occurs, but no double counting of investments. Thus, the number of projects by research area does not add up to the total number of projects. Percentages may not add up to 100% due to rounding.

At the global level, the majority of AMR-relevant R&D funding is directed towards Basic Research, followed by Therapeutics and support for Operational and Implementation research.

As the number of projects integrated within the Dynamic Dashboard has increased (plus associated countries and One Health sectors represented), a more comprehensive overview of the AMR R&D funding landscape is becoming apparent.

A visual overview of the funding flow into One Health sector/research area combinations is shown in Figure 7, highlighting the importance of Basic Research across all One Health sectors and an emphasis on Operational and Capacity Building R&D within cross-sectoral projects. The vast majority of projects in which the sector is not specified address Basic Research, which may have relevance to one or multiple sectors.
### No. of Projects and Investments (million USD)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Total</th>
<th>Human</th>
<th>Animal</th>
<th>Environment</th>
<th>Plant</th>
<th>Multiple Sectors</th>
<th>Not Specified</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Projects</td>
<td>12,093</td>
<td>9,842</td>
<td>906</td>
<td>332</td>
<td>177</td>
<td>641</td>
<td>555</td>
</tr>
<tr>
<td>Investments</td>
<td>8912</td>
<td>7499</td>
<td>552</td>
<td>89</td>
<td>58</td>
<td>533</td>
<td>180</td>
</tr>
</tbody>
</table>

### Sector Breakdown

**Basic Research**
- Human: 28%
- Animal: 29%
- Environment: 22%
- Plant: 26%
- Not Specified: 12%

**Operational**
- Human: 20%
- Animal: 18%
- Environment: 28%
- Plant: 51%
- Not Specified: 10%

**Therapeutics**
- Human: 23%
- Animal: 26%
- Environment: 7%
- Plant: 0%
- Not Specified: 12%

**Capacity Building**
- Human: 9%
- Animal: 8%
- Environment: 4%
- Plant: 4%
- Not Specified: 1%

**Diagnostics**
- Human: 7%
- Animal: 8%
- Environment: 11%
- Plant: 4%
- Not Specified: 1%

**Vaccines**
- Human: 7%
- Animal: 8%
- Environment: 11%
- Plant: 0%
- Not Specified: 2%

**Other products**
- Human: 3%
- Animal: 2%
- Environment: 5%
- Plant: 15%
- Not Specified: 8%

**Preventives Other**
- Human: 1%
- Animal: 1%
- Environment: 4%
- Plant: 0%
- Not Specified: 27%

**Promotants**
- Human: 1%
- Animal: 0%
- Environment: 7%
- Plant: 0%
- Not Specified: 0%

**Policy**
- Human: 1%
- Animal: 1%
- Environment: 1%
- Plant: 0%
- Not Specified: 3%

**Figure 7**: Heatmap showing funding (as a percentage) in each research area by One Health sector (human, animal, plant, environment). Values shown for human, animal, environment and plant health are for single sector projects only.

In terms of product-related research – i.e., those projects developing Therapeutics, Diagnostics, Vaccines, Promotants, Preventives or Other Products associated with AMR – represent a significant proportion of the total investment - 41% - equating to 3.7 billion USD.

The funding patterns observed across all sectors reflect the dominance of human health in the AMR funding landscape, with projects focused on Basic Research and Therapeutics receiving a large proportion of investment available. However, finer-scale delineation of the differences between sectors provides insights into sector-specific patterns in funding.

---

**Product-related R&D represents a significant proportion of the total investment - 41% - equating to 3.7 billion USD**

---

10 For Therapeutics, Diagnostics and Vaccines this includes products at both the Discovery and Development stages (See Categories and Definitions) [12]
**Investments in Animal Health**

Of the 757 million USD invested in animal health R&D, the majority (73%, 552 million USD, n=906 projects) supported animal health projects only, while 205 million USD (n=533 projects) was allocated to cross-sectoral projects (Figure 8).

The significant role of farmed animals (e.g., cattle, pigs and poultry) in AMR is reflected in the proportion of investments into these animal types with 64% of the total funding volume (487 million USD) (Figure 9). Close to half of the total investment in animal health targets livestock (41%, 309 million USD), followed by poultry (23%, 178 million USD).

---

**Figure 8: Cross-sectoral contribution in Animal health projects (million USD).** Smaller data values are not shown for clarity purposes.

**Figure 9: Investments in Animal health by sub sector (percentages).**
A more granular dissection of the animal health AMR R&D landscape that includes funding from cross-sectoral projects, reveals a slightly different focus in the animal health sector as compared to the human sector, with Operational and Basic Research projects receiving the larger share of funding (33%, 253 million USD and 19%, 146 million USD, respectively), followed by Capacity Building (12%, 62 million USD), as shown in Figure 10.

In terms of product-related R&D, the emphasis shifts marginally from Therapeutics (6%) to Vaccines and Diagnostics (9% each – total 18% – of the funding volume).

Figure 10: Investment (million USD) in Animal health AMR R&D and cross-sectoral contribution by research area.
Further, more in-depth analysis on specific animal health AMR R&D related topics can be found in two recently published reports using data from the Dynamic Dashboard: (i) a Hub-generated report in collaboration with the World Organisation for Animal Health (OIE), a Hub Observer, and HealthforAnimals (a Hub Stakeholder Group member), that evaluates gaps and opportunities in the area of veterinary vaccines to reduce antibiotic use [13], and (ii) an investigation of the animal health AMR R&D landscape in low and middle income countries (LMICs) [14] by the International Development Research Centre (IDRC).

**Investments in Plant & Environment Health**

The recent inclusion of plant and environmental health projects into the Dynamic Dashboard (in April 2021) provides a first evaluation of the funding landscape in these areas, albeit based on a limited number of projects to date.

**Plant Health**

Of the 78 million USD (265 projects) captured in the Dynamic Dashboard for plant health R&D, the majority of projects are single sector (74%, 58 million USD), compared to just over a quarter being cross sectoral (26%, 20 million USD), i.e., combining 1 to all 4 One Health sectors (Figure 11).

In terms of volume of funding, AMR R&D involving fruits comprises close to one quarter of the total (23%, 18 million USD). The remaining 75% of funding is distributed across projects targeting vegetables, cereals, crops and oil seeds. Notably, a number of projects remain ‘not specified’ or are categorised as ‘Other’ [12] (Figure 12). Once again, Basic Research receives the largest share of investment (37%, 29 million USD), however, Prevention R&D plays a more significant role than in other sectors (20%, 16 million USD) (Figure 13).

**Recent Animal health-related publications using Dynamic Dashboard data**

- **Animal Health AMR R&D & Vaccines**
  

- **Animal Health AMR R&D & LMICs**
  
Figure 11: Investment (million USD) in Plant health AMR R&D - single and cross-sectoral contributions.

Basic Research receives the largest share of investment; however, Prevention R&D plays a more significant role than in other sectors.

Figure 12: Investment (million USD) in Plant health AMR R&D by sub-categories.
Environment Health

The total investment in environment health AMR R&D represented in the Dynamic Dashboard equates to 182 million USD (Figure 14) across 608 projects. Notably, there is a near-equal division in terms of funding between sector-specific (49%; 89 million USD, n=332 projects) and cross-sectoral projects (51%; 93 million USD, n=276 projects). 29% of the total funding is directed towards projects that do not have a specific sector assigned. A similar amount of funding is directed to projects categorised as ‘water’ (i.e., meaning surface waters) and wastewater (both receiving 15% of the total funding volume = 27 million USD). Soil & Soil-waste projects capture 7% (13 million USD) of the total funding volume (Figure 15).

Figure 13: Investment (million USD) in Plant health AMR R&D by research area.
Figure 14: Investment (million USD) in Environment health AMR R&D - single sector and cross-sectoral contributions.

Figure 15: Investments (million USD) in Environment health AMR R&D sector by sub-categories.
In terms of Research area, the focus is on Operational research, which captures 46% of all funding in this sector (84 million USD), followed by Capacity Building (18%, 33 million USD) and Basic Research (19%, 34 million USD), as shown in Figure 16.

"Operational research captures almost half (46%) of all funding in the environmental health sector."

![Figure 16: Investments in Environment health AMR R&D sector by research area (million USD).]
2.1.3 Target infectious agents

Across all sectors, the majority of investments support R&D addressing bacteria (90%, 8054 million USD), followed by fungal, viral and parasitic infectious agents (5.7%, 512 million USD; 0.73%, 65 million USD and 0.46%, 41 million USD, respectively) (Figure 17). For a small percentage of projects, the infectious agent was ‘not specified’ (2.7%, 239 million USD). See [15] for an overview of infectious agents in scope.

The Dynamic Dashboard currently only collects viral and parasitic data for animal, environmental and plant health projects, but not for human-health projects (bacterial and fungal projects only).

When viewing the investments without human health data included i.e., across the animal, plant and environment health sectors, the proportion of the AMR R&D investment targeting bacterial pathogens decreases to 73% (1029 million USD), and a higher proportion of the funding effort is focused on fungal (6%, 79.5 million USD), viral (4%, 61.6 million USD) and parasitic (2.8%, 38.9 million USD) infectious agents (Figure 18).

On a sector-by-sector basis, the picture is similar with bacterial infectious agents the priority across all sectors. Readers are referred to Section 2.1.6 for a more in-depth study of the human pathogens.

![Figure 17: Investment in AMR R&D by infectious agent in million USD – all sectors.](image-url)
2.1.4 Who is funding AMR R&D?

Due to the availability and consistency of information, the Dynamic Dashboard currently only includes funders from the public and philanthropic sectors and not from the private-for-profit sector. The majority of funders included are of Public-Government origin (61%, n=147), followed by Private-non-profit (16%, n=23), Public-other (13%, n=41) and Public-Private funders (10%, n=3) (Figure 19). See Info Box for definition of funder type.

Of these 214 funders, 90 (42%) also support projects that are cross-sectoral (Figure 20). Only a limited number of funders (n=28, 13%) support single sector projects across multiple sectors. Over a third of the funders (n=76, 36%) focus on human health only projects,

![Diagram of investment in AMR R&D by infectious agent in million USD – animal, plant and plant only (excluding human health investments).]

Figure 18: Investment in AMR R&D by infectious agent in million USD – animal, plant and plant only (excluding human health investments).
followed by animal (n=13, 6%) and environment health (n=5, 2%). Within the Dynamic Dashboard, there are no funders that focus solely on supporting only AMR plant health.

Figure 19: Investment captured in the Dynamic Dashboard (left-hand scale; bars) and number of funders (right-hand scale, line), for all sectors, by type of funder.

Figure 20: Percentage of funders supporting sector specific, multiple sectors and cross-sectoral projects.
Differences are also observed in the research areas being targeted across the spectrum of funder types (Figure 21). Public-Government and Public-Other type funders, have a focus on Basic Research, Therapeutics and Operational R&D (collectively, >70% of spending for each funder type: 3.9 billion USD and 0.89 billion USD, respectively). Private-non-profit funders also invest heavily in these three research areas (60%, 0.87 billion USD), but there is also a focus on R&D targeting the development of vaccines, with 21% of funding flowing into this area (0.3 billion, USD). Conversely, the focal area of Public-Private funders is very much on the development of Therapeutics, with 70% (0.69 billion USD) of all investments in this area.

Notably, funding allocated to the development of Diagnostics remains limited, comprising only 1-10% of investments across all funder types.

Figure 21: Proportion of investment into research areas by funder type for all sectors. Values below 3% are not shown for clarity purposes.

Funding allocated to the development of Diagnostics remains limited, comprising only 1-10% of investments across all funder types.
2.1.5 Where are the funders located?

Overall, the 214 funders captured in the Investment Gallery are located across 46 countries plus the EU (Figure 22).

The top 10 countries (plus the EU) in terms of investment volume are highlighted, showing major contributions to AMR R&D from the US, EU, United Kingdom (UK), Germany, Australia, Switzerland, Sweden, Canada, France, Norway and Japan. Currently, however, the Dynamic Dashboard has limited information on funders originating in the African continent as well as parts of South America, South East Asia and the Middle East.

Figure 22: Geographical location of the 214 funders captured within the Investment Gallery, with the investments shown in million USD for the top 10 funders according to country (plus the EU). The large-scale funding initiatives CARB-X and GARDP have been incorporated into the funding total for the US and Switzerland, respectively, to avoid doubling counting. Readers are referred to Figure 26 for information on the funding amounts being transferred into these organisations from national and other funding sources.
Investments in AMR R&D take place in many different forms. Some funding institutions will invest in projects within their country of origin, while others fund projects internationally or via jointly funded initiatives or calls.

To provide further insight into the nature of these investments, they were labelled as either Domestic or International (for definition, see Info Box). Of the 8.91 billion USD investments made by the 214 funders represented in the Investment Gallery, 54% (4.83 billion USD, 9756 projects) was considered Domestic and 46% (4.08 billion USD, 2335 projects) as International funding (Figure 23).

**Figure 23: Percentage of AMR R&D funding considered Domestic or International.** See Info Box for definitions in this context.
Of the 4.83 billion USD considered Domestic funding, the majority was distributed to research organisations in the US (55%), followed by the UK (16%), Germany (5%) and Australia (4%). Of the 4.08 billion USD considered International funding, the majority was distributed to research organisations in the US (20%, 811 million USD), UK (14%, 573 million USD) and the Netherlands (13%, 519 million USD). See Figure 24 for the top 10 recipients in terms of international funding.

In terms of types of institutions receiving funding, the majority is invested in projects conducted by Universities (53%, 4.75 billion USD) and Public research institutions (21%, 1.89 billion USD) (Figure 25). The small percentage flowing to ‘Industry’ (3%) across all categories again reflects the fact that only public and philanthropic sources of funding are captured here. Notably, Small and Medium enterprises (SMEs) receive 13% of the funding captured in the Dynamic Dashboard, with investment totalling 1.16 billion USD. Moreover, when analysis is restricted to just product-related12 R&D (3.7 billion USD) – then the proportion of funding received by SMEs increases to 28.7% (1.06 billion USD). In comparison, Universities receive 1.43 billion USD (38.7%) and research organisations 679 million USD (18.3%) of the funding amount focused on product-related R&D. As expected, human health sector R&D projects are the main focus of each type of institution receiving funding.

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12 Projects categorised as either of the following: Therapeutics, Diagnostics, Vaccines, Promotants, Other products, Preventives Other
...the majority of funding is received for projects conducted at universities (53%) and public research institutes (21%), while SMEs receive 13% (1.06 billion USD)

![Figure 25: Proportion of funding (million USD) received according to institution type. Numbers in bold indicate total funding. Breakdown of funding per sector indicated.](image)

**Funding distributors**

In January 2021, the concept of the Funding Distributor (see Info Box) was introduced to the Dynamic Dashboard with a dedicated report. It was necessary to introduce this new concept in order to avoid double counting of investments. The report enables a more in-depth look at investments distributed and currently features two initiatives (Figure 26)
GARDP [16] and CARB-X [17] – both global non-profit partnerships dedicated to accelerating antibacterial research and directing funds into the early development pipeline of new therapeutics, diagnostics and preventives including vaccines.

Importantly, the report highlights the large and very important commitment of several funders with their shared and aligned interests. Further funding distributors are due to be added to the report in the near future, including the AMR Action Fund [18], which will invest in the later stages of the development pipeline.

**Funding Distributors**

A funding distributor is an organisation which receives funding by various funders (public & philanthropic) and uses the funds to support projects and programmes, respectively. A funding distributor is therefore a recipient of funding (grantee) as well as a funder.

The funding distributor report is the only report in the Dynamic Dashboard where both funding directions are presented – funds flowing into the initiative, and the distribution of these funds to other organisations in the form of investments.
2.1.6 Case Study: AMR R&D funding landscape for Human Priority Pathogens

To identify potential gaps and opportunities in terms of R&D funding targeting human priority pathogens (see Info Box [19–22] and Section 8.3 for definition), we evaluated the investments being made into R&D across the value chain from Basic Research to Policy.

Overall, of the 7.49 billion USD total investment in the human sector (single sector projects only) captured by the Dynamic Dashboard, over half (58%, 4.4 billion USD) targets priority bacterial pathogens, while 27% (2.06 billion USD), targets research in which the bacteria of interest are not specified.

Mapping of this funding according to priority level (Figure 27), shows that close to half (45%, 2.91 billion USD) is directed toward High priority bacteria (31%, 2.02 billion USD for R&D targeting *Mycobacterium* spp.), whereas 15% (0.96 billion USD) is provided for Critical priority bacteria, 8% (0.49 billion USD) for Medium priority and 1% (0.03 billion USD) for Watch level bacteria (only *Bordetella* is currently included in the Hub’s combined priority list13 [15]).

**Priority Pathogens – Definition**

The Dynamic Dashboard uses the following priority pathogen lists:
- WHO’s Priority Pathogen List (PPL) [19]
- US Centre for Disease Control (CDC) – List of urgent threats of AMR [20]
- European Centre for Disease Prevention and Control (ECDC) European Antimicrobial Resistance Surveillance Network (EARS-Net) [21]
- Indian Priority Pathogen List [22]

The Hub’s combined Priority Pathogen List is provided in Section 8.3

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13 See Section 8.3 for the Global AMR R&D Hub’s combined priority pathogen list

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Over half (58%, 4.4 billion USD) of total investment in the human sector captured in the Dynamic Dashboard targets priority bacterial pathogens
Examining these data at the level of individual bacterial types according to priority category (Critical, High, Medium, Watch) (Table 3) shows that *Pseudomonas* (289 million USD), *Mycobacterium* (2021 million USD) and *Streptococcus* (395 million USD) accounted for the highest proportion of funding within their respective categories – *Bordetella* (34 million USD) is the only species for the Watch category.
<table>
<thead>
<tr>
<th>Priority Level</th>
<th>Bacterial genus</th>
<th>Amount Since 2017 (million USD)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td><em>Pseudomonas</em></td>
<td>288.41</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td><em>Clostridiodes</em></td>
<td>183.52</td>
<td>19%</td>
</tr>
<tr>
<td></td>
<td><em>Escherichia</em></td>
<td>156.70</td>
<td>16%</td>
</tr>
<tr>
<td></td>
<td><em>Enterobacteriaceae</em></td>
<td>122.37</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td><em>Acinetobacter</em></td>
<td>102.30</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td><em>Klebsiella</em></td>
<td>91.23</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td><em>Enterobacter</em></td>
<td>13.94</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td><em>Proteus</em></td>
<td>3.61</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td><em>Serratia</em></td>
<td>3.37</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td><em>Providencia</em></td>
<td>0.01</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td><em>Morganella</em></td>
<td>0.00</td>
<td>0%</td>
</tr>
<tr>
<td>High</td>
<td><em>Mycobacterium</em></td>
<td>2020.83</td>
<td>69%</td>
</tr>
<tr>
<td></td>
<td><em>Staphylococcus</em></td>
<td>466.11</td>
<td>16%</td>
</tr>
<tr>
<td></td>
<td><em>Salmonella</em></td>
<td>170.51</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td><em>Neisseria</em></td>
<td>150.66</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td><em>Enterococcus</em></td>
<td>62.90</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td><em>Campylobacter</em></td>
<td>22.68</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td><em>Helicobacter</em></td>
<td>21.63</td>
<td>1%</td>
</tr>
<tr>
<td>Medium</td>
<td><em>Streptococcus</em></td>
<td>394.31</td>
<td>81%</td>
</tr>
<tr>
<td></td>
<td><em>Shigella</em></td>
<td>81.08</td>
<td>17%</td>
</tr>
<tr>
<td></td>
<td><em>Haemophilus</em></td>
<td>10.17</td>
<td>2%</td>
</tr>
<tr>
<td>Watch</td>
<td><em>Bordetella</em></td>
<td>34.14</td>
<td>100%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>4400.47</td>
<td></td>
</tr>
</tbody>
</table>

*Table 3: Funding (million USD) captured in the Dynamic Dashboard for human health according to priority category.*
Looking more closely at the Critical priority pathogens (Figure 28) shows that the family Enterobacteriaceae (comprising Escherichia, Klebsiella, Enterobacter, Proteus, Serratia and Providencia spp.) accounts for a large fraction of the funding (40%). The projects which referred to the family Enterobacteriaceae and not a specific bacterium within the family, were included in the category Enterobacteriaceae.

A more traditional way for development of potential products against bacteria was to focus on broad-spectrum antibiotics. In recent years, however, there has been a shift in the pre-clinical pipeline with a larger number of potential products focused on a single pathogenic species [1].

Table 4 outlines the current status of R&D investments for single bacterium research including Mycobacterium and the other top-ten priority pathogens. Over half of the investments in single pathogen projects are focused on Mycobacterium spp. (56%), followed by Streptococcus spp. (10%), Pseudomonas spp. (9%) and Clostridioides spp. (5%).

![Figure 28: Amount of investment (million USD) into Critical priority level bacteria.](image)
### Table 4: Current status of R&D investments for single bacterium research including Mycobacterium and top-ten other priority pathogens as captured in the Dynamic Dashboard, human sector.

<table>
<thead>
<tr>
<th>Bacteria</th>
<th>Investment for single bacterium research (million USD)</th>
<th>% of investment for single bacterium research</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Mycobacterium spp.</em></td>
<td>1993</td>
<td>56%</td>
</tr>
<tr>
<td><em>Streptococcus spp.</em></td>
<td>363</td>
<td>10%</td>
</tr>
<tr>
<td><em>Pseudomonas spp.</em></td>
<td>327</td>
<td>9%</td>
</tr>
<tr>
<td><em>Clostridioides spp.</em></td>
<td>162</td>
<td>5%</td>
</tr>
<tr>
<td><em>Salmonella spp.</em></td>
<td>144</td>
<td>4%</td>
</tr>
<tr>
<td><em>Neisseria spp.</em></td>
<td>128</td>
<td>4%</td>
</tr>
<tr>
<td><em>Escherichia spp.</em></td>
<td>91</td>
<td>3%</td>
</tr>
<tr>
<td><em>Enterobacteriaceae</em></td>
<td>81</td>
<td>2%</td>
</tr>
<tr>
<td><em>Shigella spp.</em></td>
<td>65</td>
<td>2%</td>
</tr>
<tr>
<td><em>Acinetobacter spp.</em></td>
<td>44</td>
<td>1%</td>
</tr>
<tr>
<td><em>Klebsiella spp.</em></td>
<td>39</td>
<td>1%</td>
</tr>
</tbody>
</table>

2.1.6.1 What type of research is being funded?

In terms of research areas, overall funding targeting these human priority bacterial pathogens focuses mostly on Basic Research (30%) and Therapeutics (28%), followed by Operational research (17%), as shown in Figure 29. Vaccines cover 12% of the total investment, while Diagnostics and Capacity Building cover 6% each. The breakdown is similar across the human health sector overall (see Figure 7).

A further breakdown of investment in different research areas according to the priority categories is shown in Figure 30. The proportion of investment into the research areas varied slightly across the different priority levels. For critical priority bacteria, the majority of funding is directed towards R&D for Therapeutics (44%, 421 million USD) and Basic Research (34%, 327 million USD). For Medium priority bacterial pathogens, only 4% of funding is for Therapeutics (19 million USD), while Operational R&D claims 29% (140 million USD). As priority level decreases, investment into Vaccines R&D increases (from 3-56%). A high proportion of investment in Vaccine R&D is focused on High (299 million USD) and Medium priority level (181 million USD) pathogens. Medium priority includes bacteria such as *Streptococcus spp.* and *Haemophilus spp.*, which already have vaccines either on the market or identified as a priority (*Shigella spp.*) [23].
### Figure 29: Investment (million USD) in priority level bacteria by research areas, human sector.

<table>
<thead>
<tr>
<th>Category</th>
<th>Basic Research</th>
<th>Therapeutics</th>
<th>Operational</th>
<th>Vaccines</th>
<th>Diagnostics</th>
<th>Capacity Building</th>
<th>Policy</th>
<th>Other Products</th>
<th>Preventives Other</th>
<th>Promotants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Research</td>
<td>30% 327</td>
<td>28% 421</td>
<td>17% 506</td>
<td>12% 181</td>
<td>6% 19</td>
<td>6% 13</td>
<td>1% 32</td>
<td>1% 30</td>
<td>0% 13</td>
<td>0% 19</td>
</tr>
<tr>
<td>Therapeutics</td>
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<td>Operational</td>
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<td>Vaccines</td>
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<td>Diagnostics</td>
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<td>Capacity Building</td>
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<td>Policy</td>
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<td>Other Products</td>
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<tr>
<td>Preventives Other</td>
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<td>Promotants</td>
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</tbody>
</table>

### Figure 30: Investment (million USD) in different categories of priority level bacteria by research areas, human sector. Smaller data values are not shown for clarity purposes.
2.1.6.2 Who is funding this R&D and where?

In terms of funder types, the majority of investments are provided by Public-Government (56%) followed by Private-non-profit (21%) sectors (Table 5), a breakdown similar to human health funding overall.

The majority of investments across all funder types are directed to projects where the bacteria of interest are not specified (32%) or to projects focused on Mycobacterium spp. (31%) – to aid evaluation, investments in Mycobacterium spp., are analysed separately from the high priority category (Table 5).

Among the priority groups, funding levels from Public-Government and Public-Private sectors decrease with priority ranking (from critical to medium). The Public-Other funders appear to have a higher level of investment in the High priority level (13%), while Private – non-profit funders have a higher proportion of investment in the Medium priority level (23%).

Analysis of the top 3 funders in terms of geographical location (Figure 31), reveals the US (2503 million USD), EU (795 million USD) and the UK (486 million USD) are major investors in projects targeting priority level bacteria, collectively providing 86% (3.78 billion USD) of the total funding volume in this sector.

Notably, key members of the funding landscape in this domain such as the Bill & Melinda Gates Foundation (BMGF) and CARB-X (also funded by multiple national governments) are included within the US here, while the Wellcome Trust is included within the UK, when calculating funding levels (Figure 31).

<table>
<thead>
<tr>
<th></th>
<th>Private - Non-Profit</th>
<th>Public - Government</th>
<th>Public - Other</th>
<th>Public - Private</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td>44</td>
<td>641</td>
<td>80</td>
<td>203</td>
<td>968</td>
</tr>
<tr>
<td>High</td>
<td>117</td>
<td>578</td>
<td>103</td>
<td>99</td>
<td>897</td>
</tr>
<tr>
<td>Mycobacterium spp.</td>
<td>491</td>
<td>922</td>
<td>385</td>
<td>243</td>
<td>2,041</td>
</tr>
<tr>
<td>Medium</td>
<td>303</td>
<td>137</td>
<td>41</td>
<td>6</td>
<td>487</td>
</tr>
<tr>
<td>Watch</td>
<td>9</td>
<td>4</td>
<td>3</td>
<td>19</td>
<td>34</td>
</tr>
<tr>
<td>Not specified</td>
<td>381</td>
<td>1,336</td>
<td>204</td>
<td>153</td>
<td>2,073</td>
</tr>
<tr>
<td>Total</td>
<td>1,345</td>
<td>3,618</td>
<td>815</td>
<td>723</td>
<td>6,501</td>
</tr>
</tbody>
</table>

Table 5: Amount of investment in million USD by funder type into priority level bacteria.
Figure 31: Amount of investment in million USD by top 10 funder countries and the European Union according to different priority level categories. Note: Numbers in bold indicate total funding. Smaller data values are not shown for clarity purposes.
2.2 Pipeline Gallery

The Pipeline Gallery shows the antibacterial products targeting priority pathogens in clinical development or products that have recently been approved. The representation complements the information presented in both the Investment and Incentives galleries. It features the latest reports and data from the WHO [1] and the PEW [2,3] on the current state of the global pipeline of antibacterials in clinical development, including non-traditional approaches such as bacteriophages. The consolidation of these updates within the Pipeline Gallery, provides a tool to help policy makers and stakeholders monitor the antibacterial pipeline and identify potential gaps and opportunities.
The Pipeline Gallery presents the latest analyses carried out by the WHO [1] and PEW [2,3], providing a collated overview of the current antibacterial products in clinical development, enabling a more integrated evaluation of the pipeline that includes both traditional (e.g., small molecule antibiotics) and non-traditional (i.e., antibodies, bacteriophages & phage-derived enzymes, microbiome modulating agents and miscellaneous agents) clinical agents.

There are currently 104 antibacterials and combinations in the clinical pipeline (or recently approved/marketed) (Figure 32), targeting priority pathogens\(^{14}\). This represents an increase of 25 products since the Hub’s 2020 Annual Report, and is mostly due to the inclusion, for the first time, of a comprehensive overview of non-traditional agents by the WHO (PEW updated its non-traditional products for bacterial infections in clinical development in 2017 [3]).

\(^{14}\) In the Pipeline Gallery, the priority pathogens refer to the WHO’s list of priority pathogens [19] and CDC Antibiotic Resistance Threats in the United States [20].
Of these 104 products, 71 (68%) are traditional antibacterials and 33 (32%) are non-traditional antibacterial agents. In terms of development stage, the majority of products in the pipeline are still in the early phases − Phase 1 or Phase 2 clinical trials − 71% (73) ([Figure 33] (1)) − with a large proportion of these products in the early phases of development (60%, n=45) targeting priority pathogens. The remaining (40%) of these early phase products target *Mycobacterium spp.* and *Clostridioides spp.* Moving into later development and post-approval stages the focus remains on the priority pathogens ([Figure 33]).

*The majority (71%) of products in the pipeline are still in the early phases − Phase 1 or Phase 2 clinical trials*

![Figure 33: Product development pipeline and recently approved/marketed therapeutics for human bacterial infections by phase and by type of pathogen addressed.](image)

N.B. Some products are listed by the WHO [1] and PEW [2,3] analyses as being in several phases of development, therefore the numbers shown are larger than the total number of products in development or recently approved (n=104). Total number of products shown in bold.
Of the 71 small-molecule products in the pipeline, 52 (73%) are active against priority pathogens - 29 of these products are active against at least one of the WHO Critical or CDC Urgent list of pathogens (12 of these are in Phase 1 clinical trials). The remaining traditional products target *Mycobacterium spp.* (n=14, 20%) and *Clostridioides spp.* (n=5, 7%). Non-traditional agents are similarly focused on priority pathogens (n=20, 60%) and *Clostridioides spp.* (n=13, 40%), but no products are currently in development for *Mycobacterium spp.* (Figure 34).

*Figure 34: Count of traditional small molecules antibiotics and non-traditional agents in clinical development targeting different pathogen categories.*
There has been increasing interest in recent years in the development of alternative strategies to traditional small molecules [24] with a diversity of approaches taken.

There are 11 antibodies, 4 bacteriophages and phage-derived enzymes, 10 microbiome-modulating agents, 4 immunomodulating agents and 4 miscellaneous agents (incl. anti-virulence agents) in development (categories as defined by the WHO) [1] (Figure 35). The majority of these non-traditional agents are in early clinical stages and mostly target Gram-positive bacteria, while only 2 have broad-spectrum activity against both Gram positive and Gram-negative bacteria [3].

Figure 35: Non-traditional antibacterials in clinical development, divided into sub-categories. Categories as defined by the WHO.
Innovation in the clinical pipeline

Since 2017, only 11 new antibacterial drugs have been approved. Of these, only two are categorised as meeting at least one of the WHO criteria for innovation\textsuperscript{15} - Vabomere (Vaborbactam + meropenem) and Lefamulin belong to a new chemical class. From the current traditional products in the pipeline (60 small molecules + 11 products recently marketed), less than a quarter (n=15, 21%) represent a new type of chemical class and have a new target (Table 6). For products targeting the most critical pathogens (“WHO critical” [19] and/or “CDC urgent threats” [20]) only 6 represent a new chemical class and new target.

Overall, based on the analyses by the WHO [1] and Pew [2,3], highlighted in a joint communication piece with the Global AMR R&D Hub [25], the global pipeline of antibacterials in clinical development remains insufficient to combat the growing threat of antibiotic resistance, with the current, broken antibiotics market unable to keep pace with the need for new drugs.

<table>
<thead>
<tr>
<th></th>
<th>Addressing WHO critical and/or CDC urgent pathogens</th>
<th>New chemical class and new target</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional products in pipeline (Phase 1 to Approval)</td>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td>6</td>
<td>28</td>
</tr>
<tr>
<td>No</td>
<td></td>
<td>9</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>45</td>
</tr>
<tr>
<td>11 recently marketed antibiotic products</td>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>No</td>
<td></td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11</td>
<td>0</td>
</tr>
</tbody>
</table>

\textit{Table 6: Traditional or small molecule products in clinical development or recently marketed} classified to whether they address WHO critical and/or CDC urgent pathogens and whether they represent a new chemical class and new target.

\textsuperscript{15} The WHO innovation criteria cover four factors; absence of known cross-resistance, new target, new mode of action and/or new chemical class [1]
The Incentives Gallery captures, displays and tracks on an interactive page, incentives being implemented globally that aim to improve the functioning of markets – and the broader R&D ecosystem – responsible for the development and distribution of therapeutics for the treatment of priority human bacterial infections. By clearly displaying the information along the whole value chain it aims to provide a regularly-updated global snapshot of the status of currently implemented or trialled activities. Incentives are grouped under nine categories or Incentive Strategies (see Info Box). The Gallery additionally serves as a gateway for users, so for each incentive captured, the user can access a short description and have the possibility (Drill Down > Additional Information) to access a variety of external links and documents.
The Global AMR R&D Hub’s work on incentives has focused on a collation of activities occurring along the value chain that try to support the therapeutic development ecosystem and mitigate some of the well-known challenges hindering the development, uptake and distribution of new\textsuperscript{16} agents that are urgently needed. Some of this ecosystem support is in the form of financing, and extracting investment data has enabled a quantitative enrichment of the information about incentives displayed in the Dynamic Dashboard.

The pre-approval stages of the value chain (shown in categories 01-04) in the Incentives Gallery (Figure 36), support – financial and otherwise – for R&D and translation related to discovery and pre-clinical research and phase I clinical trials. Funders at this stage include CARB-X, Joint Programming Initiative on Antimicrobial Resistance (JPIAMR) \textsuperscript{26} and the REPAIR (Replenishing and Enabling the Pipeline for Anti-Infective Resistance) Impact Fund \textsuperscript{27} (see category 01).

At the later development stages (from clinical trial phases II, III to product registration) – often viewed as the more expensive stages of therapeutic development – funders such as GARDP, the US Biomedical Advanced Research and Development Authority (BARDA) and the recently created AMR Action Fund \textsuperscript{18} are represented (see category 03).

Category 02 includes information on support and financial incentives for enhancing clinical trial conduct, such as IMI’s COMBACTE-NET and the US Clinical Trials Transformation Initiative (CTTi).

Category 04 highlights the initiatives underway to streamline regulatory requirements such as European Medicines Agency (EMA) guidance and the US Food and Drug Administration (FDA) guidance.

\textsuperscript{16} The Investment Gallery also includes old antibiotics whose precarious supply is of concern to policy makers, but this is not covered here.
To provide some insight into the scale of investment within these ‘pre-approval’ categories, we calculated funding flowing into antibacterial products (therapeutics in the discovery/development stage targeting bacteria as per our categories [12] and reflected within our Investment gallery\(^\text{17}\) (Figure 37).

This analysis allowed us to gain some insight into the funders (country-wise) and financing instruments (e.g., BMGF, CARB-X) investing in these projects. Overall, push funding for AMR relevant R&D during the early and later development (Categories 01 and 03) stages for therapeutics targeting bacterial infections totals 1.62 billion (from 89 funders located within 53 countries + EU). The top funders within this space are the US health agencies (36%, 593 million USD) and the EU (27%, 441 million USD), followed by CARB-X (15%, 244 million USD) and BMGF (4.8%, 174 million USD).

The AMR Action Fund is open to proposals and projects will be integrated into the Dynamic Dashboard as soon as information is available. A more granular evaluation of the R&D funding landscape across the value chain is provided in Section 2.1.6.

\(^{17}\) Not all of the funders in Figure 37 are highlighted in the Incentives Gallery – the analysis is to provide an indicative scale of investment. Readers are referred to the Investment Gallery to provide more detailed information on ‘push’ funding for Therapeutics -see also Section 2.1.6.
Figure 37: Total ‘push’ investment (million USD) in the early and late development phases for human therapeutics (bacterial infections) since January 2017 - top 21 largest funders by country (blue) and financing instruments (gold). Values shown are indicative to show the scale of the funding in this sector, with larger funding organisations such as CARB-X, GARDP and Wellcome highlighted to show scale of contribution rather than country of origin.

As we move to the post-approval aspects of the value chain - categories 05-09 in the gallery - from global filings and label expansion to marketing (Figure 38), the range of tools available are detailed in the form of financial and other support as well as policy mechanisms. For example, category 05 ‘Earlier and broader uptake’, provides details of the support available for new data generation and better use of data plus mechanisms to support smaller developers in the initial post-launch phases, e.g., US BARDA’s Strategic National Stockpile (SNS) and Reserve Fund (SRF) and US IDSA (Difficult to treat infections guidance series). Efforts to improve capture of the movement and activity with respect to improving the supply chain (category 06) of older antibiotics are also highlighted.
On the important question of improving attractiveness of the market (category 07), the gallery provides entries for the UK’s Value-based subscription model project, Sweden’s Exceptional procurement pilot and new additions for Germany’s reimbursement incentive for antibiotics (Act on Fair Competition among the Statutory Health Insurance Funds (GKV-FKG) – and its application for Cefiderocol (Fetroja) [28] – as well as the re-introduction of The Pioneering Antimicrobial Subscriptions to End Upsurging Resistance (PASTEUR) Act, to US Congress in June 2021[29].

The PASTEUR Act aims to provide a lifeline for the antibiotics pipeline, by offering subscription-based government contracts for access to innovative antibiotics that address the most urgent patient needs. Key elements of the PASTEUR Act were recently included within the US CURES 2.0 [30] legislation introduced to Congress in November 2021.

There are also a number of recent EU efforts, including the new Pharmaceutical Strategy for Europe [31] that was announced in November 2020 to address investment and awareness for AMR, and the newly-established Health Emergency Preparedness and Response Authority (HERA) [32]. Other initiatives include the new Horizon Europe research call to develop work that prepares for a European pull incentive for new antimicrobials [33] – progress made in these efforts will be reflected in the Incentives Gallery as necessary.

Major efforts by the WHO, PEW and others to expedite sustainable global patient access to priority therapeutics are also included – for example, WHO AWaRe (Access, Watch, Replace) [34], WHO Essential Medicines List (EML) and the recently published EML Antibiotic Book, as well as the SECURE (Expanding sustainable access to antibiotics) [35] initiative – (see category 08). SECURE is a GARDP and WHO initiative with support from United Nations Children’s Fund.
Priority signalling is summarised in category 09, with entries including the WHO Priority Pathogens List (PPL) and Target Product Profiles. WHO is also currently developing a fungal priority pathogen list (FPPL), which will be added to category 09 once published.

Overall, a range of interesting, targeted initiatives to improve efficiencies and address some of the challenges along the value-chain are visible, but their collective scale and economic impetus likely remains too weak.

Readers are referred to a recent Global AMR R&D Hub report [36] (and associated Policy Briefs) that further explores the market attractiveness of developing antibiotics and diagnostics targeting the greatest priority patient needs addressing AMR, providing key insights and recommendations.
3. Conclusions

The Global AMR R&D Hub’s 2nd Annual Analysis, incorporating 12,093 projects worth a total of 8.91 billion USD across 4 One Health sectors, represents the most comprehensive mapping of the AMR R&D funding landscape to date.

With the Integration of investments from across the One Health continuum (human, animal, plant and environment), an expanded range of infectious agents (bacteria, fungus, viruses and parasites), projects and investments in AMR R&D globally, the Dynamic Dashboard now offers a robust knowledge foundation that can be leveraged to identify gaps and opportunities, not only for funding and policy decisions but also in support of partnerships and collaborations across sectors.

Global funding for AMR R&D remains in an upward trajectory: In terms of AMR R&D funding, year-on-year growth in investments are visible with an increase in public and philanthropic investment in AMR R&D between 2017 and 2019, from 1.65 billion USD in 2017 to 1.8 billion USD in 2019. As a more complete dataset emerges for 2020 and 2021, the impact of Covid-19 on AMR R&D funding will be evaluated more thoroughly.

Funding for Human health dominates the AMR R&D landscape: The current analysis highlights the enduring emphasis of AMR R&D funding on human health, with more than 84% of funding captured by projects solely focused on this sector (7.4 billion USD) – over half of this funding (58%, 4.4 billion USD) targets priority bacterial pathogens.

Across all sectors, Basic Research, Therapeutics and Operational R&D represent the top 3 research areas in terms of investment. When viewed as a collective ‘product-relevant’ R&D also gains significant support in terms of investments (41% of total funding volume); however, funding gaps are apparent, for example, investments in R&D for Diagnostics and Vaccines are approximately two thirds lower than for Therapeutics.

Evaluation of cross-sectoral AMR R&D is now possible: Due to the inclusion of all 4 One Health sectors (albeit with limited projects numbers in both the plant and environmental health sectors - 3% of funding), we are able, for the first time, to provide an initial evaluation of funding for cross-sectoral projects – showing that 6% of funding for AMR R&D targets projects that span more than one ‘One

\[18\] 41% of all total funding in the Dynamic Dashboard (3.68 billion USD). Product relevant R&D encompasses R&D on Therapeutics, Diagnostics, Vaccines, Preventives Other, Promotants and Other Products. See definitions in Categories and Definitions [12]
Health’ sector – with the emphasis on Operational and Capacity Building R&D within these multi-sector projects.

A key focus for animal health AMR R&D is livestock: This research area comprises close to half (41%, 309 million USD) of all funding in this sector.

Despite a limited number of projects, nascent trends are emerging in plant and environmental health AMR R&D: Within the plant health sector, a strong focus is placed on Prevention AMR R&D, whereas Operational and cross-sectoral R&D are emphasised in the environmental health sector.

There are 104 products in the antibacterial clinical pipeline targeting priority pathogens. The collated information from the WHO and PEW analyses, highlights a pipeline dominated by products still in the early stages of clinical development (Phase 1 or 2), with less than a quarter of products attaining innovative status (according to the WHO classification).

Support to overcome some of the economic challenges in therapeutic markets following approval shows that the landscape remains ad hoc, small-scale and initiated by just a few countries globally: The Incentives Gallery displays the activities and measures implemented globally occurring along the value chain that try to support the therapeutic development ecosystem and mitigate some of the well-known challenges hindering the development, uptake and distribution of new agents that are urgently needed.

Further geographical and sectoral information required for a more comprehensive overview of the global AMR R&D funding landscape. Although the Dynamic Dashboard now covers a larger number of projects, geographic scope and One Health sectors, limitations need to be considered, especially with regards completeness of data and geographical coverage. Even within the datasets of individual funders, some projects may be missing. Institutional and private funding as well as investments where data could not be accessed from public and philanthropic funders are not covered.

19 The Investment Gallery also includes old antibiotics whose precarious supply is of concern to policy makers, but this is not covered here
4. Next Steps

The Dynamic Dashboard will continue to mature and evolve, expanding its depth and breadth and offering insights and guidance into the gaps and opportunities in AMR R&D across all One Health sectors.

Over the next year, we plan to continue further populating the Investment Gallery with projects across the One Health spectrum in order to enrich the landscape and funding trend analysis. An increase in the number of projects integrated covering the animal, plant and environmental health sectors will ensure more meaningful insights into the AMR R&D landscape.

To facilitate the increased scope of the Gallery and projects integrated, efforts are currently being made to (semi)-automate the data import and categorisation process. This will significantly reduce the time taken to integrate projects into the Dynamic Dashboard and increase standardisation across the categorisation process. Increased effort will also be focused on improving representation of all funder types, including institutional and private-for-profit funders and those located within countries currently underrepresented within the Dynamic Dashboard, including those situated within LMICs. Further outreach and contacts within the underrepresented regions are currently being sought.

For the Pipeline Gallery, we will continue compiling data from the WHO on progress in the development of AMR-relevant antibacterials in clinical development. To ensure added value, we will modify and expand coverage.

The Incentives Gallery provides a central repository of information on the life cycle of antibacterial development, with the recent movement in the field of incentives reflected in regular updates. Many possibilities remain in place to expand and supplement this offering (for example adding quantitative information to each listing, adding details about access/stewardship mechanisms/conditions attached to an initiative and further supporting evidence in the field) – these will continue to be explored as we progress into 2022.
CALL FOR DATA

The analyses are only as good as the data within the Dynamic Dashboard – and we continue efforts to increase coverage geographically – especially within the southern hemisphere – and data on investments made by the private sector. Funders and investors that have information about AMR-related R&D projects are encouraged to share this information with us.

Please contact us at the Global AMR R&D Hub
globalamrhub@dzif.de
5. Methodology

For full details of methodology used for the process for collecting AMR R&D investments, quality control measures, how categorisation of projects was conducted, the limitations of our data, the definitions used for the categorisation fields and the list of infectious agents included in the Dynamic Dashboard please refer to ‘Dynamic Dashboard – Data collection, processing, categorization and presentation’ [37].

In brief, projects addressing AMR-relevant R&D within the human, animal, plant and environmental One Health sectors were collected by searching relevant funder databases and the Dimensions database [38], by either using the set of standard search terms (as described in [39]) and/or by using specific keywords developed by members of the Global AMR R&D Hub Secretariat in consultation with external experts. Only public and philanthropic sources of funding are included at this time. All data sources used are outlined in the Dynamic Dashboard’s Library [39].

To present AMR R&D information at a level that is informative to the users of the Dynamic Dashboard, projects within the Investment Gallery were categorised, minimally, according to One Health sector(s) (human, animal, plant and environment or not-specified), research area (e.g. Basic Research, Therapeutics, Diagnostics, Preventives, Vaccines, Promotants, Operational, Capacity Building, Policy) and infectious agent (e.g. Bacteria, Fungus, Virus, Parasite) (see [12] for further details regarding the categories and definitions, for each One Health sector). For the human health sector, only information on bacterial and fungal pathogens are currently presented.

The methods used for integrating the information from the WHO [1] and PEW [2,3] regarding the antibacterial clinical pipeline are described in ‘Global AMR R&D Hub approach for presenting the pipeline of antibacterials in clinical development’ [40].

As information is continually updated in all three galleries of the Dynamic Dashboard, this report is based on the data available within the Dynamic Dashboard as at 1st September 2021. Only relevant projects that were active on 1st January 2017 or that started after this date are included in the Dynamic Dashboard20.

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20 This timeframe may be expanded upon at a later stage of development to provide a repository of historical AMR R&D
For analysis of the Investment Gallery, all data entries were subject to manual quality control (data cleaning) and curation. Prior to the data freeze on 1st September 2021, the completeness of each project was checked and missing information on research organisations, budget, start and end dates of projects, funder information etc, was added if necessary. The project budgets were then divided according to the One Health sectors, research areas and infectious agents. The quality-controlled dataset, was then subject to further in-depth analysis using Microsoft Excel 2019.
6. References

5. Global AMR R&D Hub Dynamic Dashboard (globalamrhub.org)
8. Global AMR R&D Hub, 2020. Special Newsletter: Advancing the One Health response to AMR. Available at: https://archive.newsletter2go.com/?n2g=guv621jn-hnjor7dt-jna
17. CARB-X, Combating Antibiotic-Resistant Bacteria. https://carb-x.org/
21. European Centre for Disease Prevention and Control. European Antimicrobial Resistance Surveillance Network (EARS-Net), Data collection and analysis. [cited 2019 1 October]; Available at:


32. European Commission, Brussels. Sep. 16, 2021. Introducing HERA, the European Health Emergency preparedness and Response Authority, the next step towards completing the European Health Union. Available at: https://tinyurl.com/ms9r2eu5

33. Funding & tenders (europa.eu) Development, procurement and responsible management of new antimicrobials (HORIZON-HLTH-2021-IND-07-02), 22 June 2021. Available at: https://tinyurl.com/4xbu9fs

34. AWaRe. Access, Watch, Reserve. Available at: adoptaware.org

35. SECURE, GARDP & WHO. https://gardp.org/what-we-do/secure/


38. Dimensions.ai, Linked research data from idea to impact.


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8. Appendices

8.1 Caveats/limitations

Interpretation: Care should be taken in drawing conclusions about the AMR R&D landscape from the information currently presented in the Dynamic Dashboard especially in regards to identifying gaps in research needs and making statements on global activity or product-specific R&D. This is because of data gaps including geographical representativeness and the current lack of information about private sector or institutional investments.

Comparison: From the data presented it is evident that we may still have considerable gaps in data collection. Also, the search terms have evolved during the period of initial data collection, the data extraction methods differ between sources, due to the nature of the data source, and the timing of data collection and updates from funders and integration within the Dynamic Dashboard.

Updates: The analysis is based on the status of information as at 1st September 2021, as referenced throughout the analysis report. Due to the nature of the Dynamic Dashboard, both the data and definitions for categorisation will be updated regularly and is subject to retrospective revision. Therefore, both new and existing data may vary between the update dates. When referencing information from the Dynamic Dashboard it is vital to refer to the specific date of data extraction. Projects/investments awarded after this date are currently not recorded.

Data Scope / Maturation: The Global AMR R&D Hub has taken a staged approach to presenting information, the most recent inclusion being the addition of plant and environment projects (April 2021). The information in the Dynamic Dashboard covers AMR relevant R&D regarding human, animal, plant and environment sectors, and includes information on bacterial, fungal and other infectious agents. However, the data for the human health projects only includes bacterial and fungal pathogens.

Completeness (by type of funder): Currently only R&D funded by public funders and philanthropic organisations is included in the Dynamic Dashboard. Work is underway to obtain and represent private sector R&D funding, which is vital to be able to obtain a more comprehensive overview of the AMR R&D landscape.

Completeness (global): Data from a considerable number of sources has been collected – see Data Sources – Global AMR R&D Hub (globalamrhub.org). Collecting data from the Members of the Global AMR R&D Hub was prioritised. It needs to be highlighted that information from a number of funders is missing. Particularly coverage of funders from the Southern hemisphere and low- and middle-income countries is still limited.
Completeness (per country): In addition, not all funders, investments and/or projects have been captured from countries. Both the global and coverage per country will improve as the amount of information captured by the Dynamic Dashboard increases over time.

Completeness (per type of funding): Our initial data set are likely skewed to certain types of funding streams/vehicles, such as direct grant support for projects and personnel. As our dataset matures, the hope is that we will be able to represent all ‘push-type’ funding (support for R&D inputs) regardless of the type of vehicle, this is again due the readiness of availability of initial data.

Completeness of capturing AMR-relevant R&D: The search terms used determine and may limit the range of relevant projects that could be identified.

Data accuracy: The Secretariat has relied on the completeness and accuracy of the original data from the funders. However, any obvious discrepancies, errors or gaps were investigated. The limited information contained in abstracts limits the interpretation and categorisation. With the large number of projects/investments collected, it is not possible to investigate more detailed information sources, such as detailed descriptions, reports, publications etc. arising from projects.

Multi-beneficiary challenges: For projects where several institutions are supported, funding information for all individual partners is normally not available. This will lead to inflated numbers for some countries/research organisations and an artificial lowering of numbers for others.21

Limitations in data processing/presentation:
As mentioned above, if a project is relevant to more than one research area, R&D stage or bacteria, the project budget is split accordingly. However, we did not split the number of projects. A project which is relevant to more than one research area, R&D stage or bacteria will be counted multiple times in the specific report, but this does not affect the overall total number of projects.

It was decided to choose the exchange rates to US Dollar and Euro on the start date of the project. For currencies where the exchange rate fluctuates (sometimes strongly) over time, this may mean that investments are over- or under-estimated. This method was chosen as it can be clearly defined.

It was decided not to factor in adjustments for inflation rates, since it is considered that having reliable information about inflation rates from across the world since January 2017 is challenging. It would also have required additional processing of the budget information adding complexity to the IT solution.

Sometimes a project/investment is composed of sub-projects, each with their own entry in the database. It is planned to develop tools that will link such sub-projects into the overarching project.

Projects are included that are active on 1 January 2017 or later. With the time period of 2017 being far enough in the past, all projects that could be found with the search terms used will have been captured.

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21 For example, for collaborative projects funded by the EU, the entire EU contribution is allocated to the coordinator and for IMI projects to the managing entity for the EU-contribution.
collected. For later years, especially as from 2021, there are still many projects that have not yet been collected because the awards have only just been announced or the search was carried out before the awards were announced.

8.2 Categories

8.3 Priority Pathogens list

Genus of priority bacteria and inclusion criteria for the Dynamic Dashboard

<table>
<thead>
<tr>
<th>Priority^</th>
<th>Bacterial genus</th>
<th>Inclusion criteria for the Dynamic Dashboard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td>Acinetobacter</td>
<td>All Acinetobacter included.</td>
</tr>
<tr>
<td></td>
<td>Clostridioides</td>
<td>Clostridioides (or Clostridium) difficile was included. All other Clostridioides and Clostridium were individually assessed for inclusion.</td>
</tr>
<tr>
<td></td>
<td>Enterobacter</td>
<td>All Enterobacter included.</td>
</tr>
<tr>
<td></td>
<td>Enterobacteriaceae</td>
<td>Enterobacter spp., Escherichia coli, Klebsiella pneumonia, Proteus spp. Providencia spp. and Serratia spp. were included. In addition, projects that just mentioned Enterobacteriaceae, without further specification, were included. Any other bacteria in the Enterobacteriaceae family were individually assessed for inclusion.</td>
</tr>
<tr>
<td></td>
<td>Escherichia</td>
<td>Escherichia coli was included. Any other Escherichia were individually assessed for inclusion.</td>
</tr>
<tr>
<td></td>
<td>Klebsiella</td>
<td>Klebsiella pneumonia was included. Any other Klebsiella were individually assessed for inclusion.</td>
</tr>
<tr>
<td></td>
<td>Morganella</td>
<td>All Morganella included.</td>
</tr>
<tr>
<td></td>
<td>Proteus</td>
<td>All Proteus included.</td>
</tr>
<tr>
<td></td>
<td>Providencia</td>
<td>All Providencia included.</td>
</tr>
<tr>
<td></td>
<td>Pseudomonas</td>
<td>Pseudomonas aeruginosa was included. Any other Pseudomonas were individually assessed for inclusion.</td>
</tr>
<tr>
<td></td>
<td>Serratia</td>
<td>All Serratia included.</td>
</tr>
<tr>
<td>High</td>
<td>Campylobacter</td>
<td>All Campylobacter included.</td>
</tr>
<tr>
<td></td>
<td>Enterococcus</td>
<td>Enterococcus faecium and Enterococcus faecalis were included. Any other Enterococcus were individually assessed for inclusion.</td>
</tr>
<tr>
<td></td>
<td>Helicobacter</td>
<td>Helicobacter pylori was included. Any other Helicobacter were individually assessed for inclusion.</td>
</tr>
<tr>
<td></td>
<td>Mycobacterium</td>
<td>Mycobacterium tuberculosis was included. Any other Mycobacterium were individually assessed for inclusion.</td>
</tr>
<tr>
<td></td>
<td>Neisseria</td>
<td>Neisseria gonorrhoeae and Neisseria meningitidis was included. Any other Neisseria were individually assessed for inclusion.</td>
</tr>
<tr>
<td></td>
<td>Salmonella</td>
<td>All Salmonella included.</td>
</tr>
<tr>
<td></td>
<td>Staphylococcus</td>
<td>Staphylococcus aureus was included. Any other Staphylococcus were individually assessed for inclusion.</td>
</tr>
<tr>
<td>Medium</td>
<td>Streptococcus</td>
<td>Streptococcus pneumoniae, group A Streptococcus (S. pyogenes and group B Streptococcus (S. agalactiae) were included. Any other Streptococcus were individually assessed for inclusion.</td>
</tr>
<tr>
<td></td>
<td>Haemophilus</td>
<td>Haemophilus influenzae was included. Any other Haemophilus were individually assessed for inclusion.</td>
</tr>
<tr>
<td></td>
<td>Shigella</td>
<td>All Shigella included.</td>
</tr>
<tr>
<td>Watch</td>
<td>Bordetella</td>
<td>Bordetella pertussis was included. All other Bordetella were checked to see if there was a published resistance issue</td>
</tr>
</tbody>
</table>

^Priority level used for visualisations on the Dynamic Dashboard.
The World Health Organisation’s (WHO) Global Priority List of Antibiotic-Resistant Bacteria [1], the United States of America’s Centers for Disease Control and Prevention (CDC) Antibiotic Resistant Threats in the United States 2019 [2], the bacteria included in the European Centre for Disease Prevention and Control’s (ECDC) European Antimicrobial Resistance Surveillance Network (EARS-Net) [3] and the Indian Priority Pathogen List [4] jointly developed by the Department of Biotechnology (DBT), Government of India, and the WHO India Office, were used to develop a combined list of priority bacteria with a drug-resistance issue. It was considered that all research into these bacteria, irrespective of the drug-resistance profile, would be relevant to advance efforts to address antimicrobial resistance.

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To cite the report, please use the following: Global AMR R&D Hub (2021). Annual Report 2021: The Global AMR R&D Funding Landscape