Dynamic Dashboard - List of Infectious Agents with a relevant AMR issue

Section A: Categories applicable to all sectors

Bacteria / gram variable

This category includes the bacteria that are considered:

- gram variable, meaning they may stain either negative or positive
- Atypical, meaning they do not colour with Gram staining but rather remain colourless, or it is difficult to see the Gram reaction
- Acid fast

Bacteria / Other gram negative

The category includes any gram negative bacteria considered to have a drug resistance issue that are not listed individually (see section B and C). This will also include projects that are specifically conducting R&D on gram negative bacteria without specifying which bacterium.

Bacteria / Other gram positive

The category includes any gram positive bacteria considered to have a drug resistance issue that are not listed individually (see section B -D). This will also include projects that are specifically conducting R&D on gram positive bacteria without specifying which bacterium.

Bacteria / Not specified

Includes projects conducting R&D relevant to AMR that do not specify which bacterium or Gram reaction.

Section B: List of Infectious Agents relevant for AMR R&D in Humans

1. Bacterial Pathogens

Categorization and inclusion methodology for human bacterial pathogens

The World Health Organization'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.

For the categorization process, only the bacterial genus level (noting the family *Enterobacteriaceae* was also included) was used and is displayed. Table 1 list the genus included in categorization and the rules applied for inclusion based on the aforementioned priority lists.

When projects included bacteria other than those listed in Table 1 an individual assessment was performed by the Secretariat to determine if there is a known drug-resistance issue. This assessment included searching the literature and reaching a consensus within the Secretariat if the bacteria has a known drug- resistance issue or not. Where consensus was not reached or there was ambiguity in the literature bacteria were parked and further investigation was conducted.

The list of additional bacteria and the outcomes from the assessment are provided in Table 2. Please note that these lists will be continually updated.

Table 1 - Genus of priority bacteria and inclusion criteria for the Dynamic Dashboard

Priority^	Bacterial genus	Inclusion criteria for the Dynamic Dashboard
Critical	*Acinetobacter*	All *Acinetobacter* included.
	Clostridioides	*Clostridioides* (or *Clostridium*) *difficile* was included. Any other *Clostridioides* and *Clostridium* were individually assessed for inclusion.
	Enterobacter	All *Enterobacter* included.
	Enterobacteriaceae	*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.
	Escherichia	*Escherichia coli* was included. Any other *Escherichia* were individually assessed for inclusion.
	Klebsiella	*Klebsiella pneumonia* was included. Any other *Klebsiella* were individually assessed for inclusion.
	Morganella	All *Morganella* included.
	Proteus	All *Proteus* included.
	Providencia	All *Providencia* included.
	Pseudomonas	*Pseudomonas aeruginosa* was included. Any other *Pseudomonas* were individually assessed for inclusion.
	Serratia	All *Serratia* included.
High	*Campylobacter*	All *Campylobacter* included.
	Enterococcus	*Enterococcus faecium* and *Enterococcus faecalis* were included. Any other *Enterococcus* were individually assessed for inclusion.
	Helicobacter	*Helicobacter pylori* was included. Any other *Helicobacter* were individually assessed for inclusion.
	Mycobacterium	*Mycobacterium tuberculosis* was included. Any other *Mycobacterium* were individually assessed for inclusion.
	Neisseria	*Neisseria gonorrhoeae and Neisseria meningitis* was included. Any other *Neisseria* were individually assessed for inclusion.
	Salmonella	All *Salmonella* included.
	Staphylococcus	*Staphylococcus aureus* was included. Any other *Staphylococcus* were individually assessed for inclusion.
Medium	*Streptococcus*	*Streptococcus pneumoniae,* group A *Streptococcus* (*S. pyogenes* and group B *Streptococcus* (*S. agalactiae*) were included. Any other *Streptococcus* were individually assessed for inclusion.
	Haemophilus	*Haemophilus influenzae* was included. Any other *Haemophilus* were individually assessed for inclusion.
	Shigella	All *Shigella* included.
Watch	*Bordetella*	*Bordetella pertussis* was included. All other *Bordetella* were checked to see if there was a published resistance issue

^°Priority level used for visualisations on the Dynamic Dashboard

Table 2 - Other bacteria with a drug resistance issue included in the Dynamic Dashboard

Genus	**Species**	**Gram stain**
Actinomycetes	*Actinomycetes* spp.	positive
Burkholderia	*B. cenocepacia*	negative
	B. cepacia	
	B. mallei	
	B. multivorans	
	B. pseudomallei	
	B. vietnamiensis	
Chlamydia	*C. trachomatis*	negative
Clostridium	*C. botulinum*	positive
	C. perfringens	
Coxiella	*C. burnetti*	negative
Chronobacter	*Cronobacter* spp., formerly *Enterobacter sakazakii*	negative
Corynebacterium	*C. diphtheriae*	positive
Cutibacterium	*C. acnes*	positive
Enterococcus	*E. hirae*	positive
Helicobacter	*H. cinaedi*	negative
Listeria	*L. monocytogenes*	positive
Moraxella	*M. catarrhalis*	negative
Mycobacterium	Non tuberculosis mycobacterium (NTM) as a group	variable
	M. abscessus	
	M. africanum	
	M. avium	
	M. kyorinense	
	M. leprae	
	M. ulcerans	
Mycoplasma	*M. genitalium*	variable
	M. pneumoniae	
Porphyromonas	*P. gingivalis*	negative
Staphylococcus	*S. epidermidis*	positive
Streptococcus	*S. mitis*	positive
Treponema	*T. pallidum*	negative
Ureaplasma	*Ureaplasma* spp.	variable
Vibrio	*V. alginolyticus*	negative
	V. cholerae	
	V. vulnificus	

2. Fungal pathogens

Categorization and inclusion methodology for human fungal pathogens

The human fungal pathogen list (Table 3) was developed in consultation with experts who are contributing to the ongoing development of the World Health Organization's (WHO) Human Fungal Priority Pathogen list. Once the WHO list is finalized and published, we will update the current fungal pathogen list accordingly as part of the continual maturation of the Dynamic Dashboard.

For the categorization process, only pathogen genus or family were used and are displayed in the Dynamic Dashboard. All species within the listed genus or family were included and some representative species are listed in the tables. When projects included species that are not listed in the table below and with a relevance for AMR, they were categorized as fungus-other.

Table 3 - Fungus with a drug resistance issue included in the Dynamic Dashboard

Fungus Genus	**Species include, but not limited to**
Aspergillus	*A. nidulans; A. fumigatus complex; A. niger complex; A. flavus complex; A. ustus complex; A. terreus complex*
Candida	*C. auris; C. albicans; C. glabrata; C. tropicalis; C. krusei*
Cryptococcus	*C. gattii; C. neoformans (serotypes A, D & AD)*
Epidermophyton	AMR relevant species that belongs to the *Epidermophyton* genus.
Pneumocystis	*P. jirovecii* (previously known as *P. carinii*)
Histoplasma	*H. capsulatum*
Fusarium	*F. solani; F. oxysporum; F. subglutinans; F. temperatum; F. verticilloides; F. falciforme; F. solani sensu lato; F. keratoplasticum; F. oxysporum; F. sacchari; F. petrophilium; F. graminearum*
Coccidioides	*C. posadasii; C. immitis*
Sporothrix	*S. schenckii; S. brasiliensis*
Blastomyces	AMR relevant species
Fonsecaea	*F. pedrosoi*
Cladophialophora	AMR relevant species that belong to the *Cladophialophora* genus
Phialophora	*P. verrucosa*
Rhizopus	AMR relevant species that belong to the *Rhizopus* genus
Mucor	*M. circinelloides; M. irregularis*
Trichophyton	*T. Asahii; T. rubrum; T. mentagrophytes*
Microsporum	AMR relevant species that belong to the Microsporum genus
Lichtheimia	AMR relevant species that belong to the Lictheimia genus
Mucorales Other	AMR relevant species that belong to the Mucorales order, not listed above
Ascomycota Other	AMR relevant species that belong to the Ascomycota phylum/division, not listed above
Basidiomycota Other	AMR relevant species that belong to the Basidiomycota phylum/division, not listed above
Not-specified	AMR relevant fungal pathogen, with no specific details given
Other	AMR-relevant fungal pathogen not covered by any of the categories listed above

Section C: List of Infectious Agents relevant for AMR R&D in Animals

Categorization and inclusion methodology for animal pathogens relevant to AMR

A pathogen list relevant to AMR R&D for animals was created based on OIEs guidance documents resulting from consultation of two ad hoc Groups on 'Prioritization of Disease for which Vaccines could reduce Antimicrobial Use in Animals'.

- Pigs, poultry and fish (April 2015) AHG_AMUR_Vaccines_2015 and
- Cattle, sheep and goats (May 2018) AHG_AMUR_Vaccines_Ruminants_2018

In addition, relevant animal pathogens with an unmet need for AMR were included per input from the experts consulted by the Secretariat for the development of the animal-specific categorization fields of the Dynamic Dashboard.

For the categorization process, only pathogen genus or family level were used and are displayed in the Dynamic Dashboard. All species within the listed genus or family were included and some representative species are listed in the tables. When projects included species that are not listed in the tables below and with a relevance for AMR, they were categorized as virus-other, fungus-other and parasite-other, respectively. In the case of bacterial infections, they were categorized as other and according to gram staining (other-gram positive, other-gram negative and other-gram variable).

Table 4 – Animal Bacterial Pathogens

Bacterial Genus	**Species include, but not limited to**
Actinobacillus	*Actinobacillus pleuropneumoniae*
Aeromonas	*Aeromonas hydrophila*
Anaplasma	*Anaplasma marginale*
Bacillus	*Bacillus anthracis*
Bibersteinia	*Bibersteinia trehalosi*
Bordetella	*Bordetella bronchiseptica*
Brachyspira	All *Brachyspira* included
Brucella	*Brucella suis, Brucella abortus, Brucella ovis, Brucella melitensis*
Campylobacter*	All *Campylobacter* included
Chlamydiaceae	All *Chlamydia* included
Clostridium	*Clostridium perfringens*
Corynebacterium	All *Corynebacterium* included
Dermatophilus	*Dermatophilus congolensis*
Dichelobacter	*Dichelobacter nodosus*
Edwardsiella	*Edwardsiella ictaluri*
Ehrlichia	*Ehrlichia ruminantium*
Escherichia*	All *Escherichia* included
Flavobacterium	*Flavobacterium columnare*
Fusobacterium	*Fusobacterium necrophorum*
Haemophilus	*Haemophilus parasuis*
Histophilus	*Histophilus somni*
Lawsonia	*Lawsonia intracellularis*
Leptospira	All *Leptospira* included
Mannheimia	*Mannheimia capricolum, Manheimia haemolytica*
Mycobacterium	*Mycobacterium bovis, Mycobacterium avium* (paratuberculosis)
Mycoplasma	*Mycoplasma agalactiae, Mycoplasma hyopneumoniae*
Pasteurella	*Pasteurella multocida*
Photobacterium	All *Photobacterium* included

Piscirickettsia	*Piscirickettsia salmonis*
Pseudomonas*	All *Pseudomonas* included
Salmonella*	All *Salmonella* included
Staphylococcus*	*Staphylococcus aureus, Staphylococcus hyicus, Staphylococcus pseudintermedius*
Streptococcus	*Streptococcus agalactiae, Streptococcus suis, Streptococcus uberis*
Trueperella	*Trueperella pyogenes*
Vibrio	All *Vibrio* included
Yersinia	*Yersinia rukerii*

*Any bacteria with relevance for AMR but not included in bacteria genus names highlighted in bold indicate a human priority pathogen as described above.

Table 5 – Animal Viral Pathogens

Virus Family	
Arteriviridae	Porcine Reproductive and Respiratory Syndrome virus (PPRS)
Birnaviridae	Infectious Bursal Disease virus (IBDV)
Coronaviridae	Bovine coronavirus (BCoV), Avian coronavirus/Infectious bronchitis virus (IBV)
Orthomyxoviridae	All influenza viruses included
Paramyxoviridae	Peste des petits ruminants virus (PPRV), Bovine Respiratory Syncytial Virus (BRSV)
Pestivirus	Bovine Virus Diarrhoea Virus (BVDV)
Poxviridae	Goatpox Virus, Sheeppox Virus
Reoviridae	Bluetongue virus, Rotavirus

Table 6 – Animal Fungal Pathogens

Fungus Genus	
Aspergillus	All *Aspergillus* included
Candida	All *Candida* included
Cryptococcus	All *Cryptococcus* included
Mucorales	All *Mucorales* included

Table 7 – Animal Parasitic Pathogens

For the categorization process, parasites were grouped into protozoa, helminths and ectoparasites.

Parasites	
Protozoa-*Babesia*	All *Babesia* included
Protozoa-*Cryptosporidium*	*Cryptosporidium parvum*
Protozoa-*Eimeria*	All *Eimeria* included
Protozoa-*Theileria*	*Theileria annulata, Theileria parva*
Protozoa-*Trypanosoma*	All *Trypanosoma* included
Helminths-*Nematodes*	Mostly families: *Trichostrongylidae*, *Molineidae*, *Ancylostomatidae, Chabertiidae*
Helminths-Other	For example trematoda such as *Fasciola hepatica*
Ectoparasites	All ectoparasites are included

Section D: List of Infectious Agents relevant for AMR R&D in Plants

Categorization and inclusion methodology for plant pathogens relevant to AMR

A pathogen list relevant to AMR R&D for plants was created based on input from the experts consulted by the Secretariat for the development of the plant-specific categorization fields of the Dynamic Dashboard. Only bacterial and fungi-relevant plant pathogens were included. For fungal pathogens the Fungicide Resistance Action Committee (FRAC) pathogen list was considered (https://www.frac.info/docs/default-source/publications/pathogen-risk/frac-pathogen-list-2019.pdf). Fungal pathogens listed by FRAC as having a high risk of development of resistance to fungicides (Table 1) were categorized by genus level (Table 9 below), while fungal pathogens listed by FRAC as having a medium risk of development of resistance to fungicides (Table 2) were categorized as one group termed Fungus-Medium Priority not by individual genus level (Table 10 below).

For the categorization process, only pathogen genus were used and are displayed in the Dynamic Dashboard. All species within the listed genus were included and some representative species are listed in the tables. When projects included species that are not listed in the tables below they were deemed not relevance for AMR. Plant projects addressed pathogens listed in the human and animal health sectors were included and categorized as described above.

Table 8 – Plant Bacterial Pathogens

Bacterial Genus	**Species include, but not limited to**
Acidovorax	Acidovorax avenae ssp
Burkholderia	Burkholderia glumae
Erwinia	Erwinia amylovora
Pseudomonas	Pseudomonas syringae
Ralstonia	Ralstonia solanacearum
Xanthomonas	All Xanthomonas include
Xylella	Xylella fastidiosa

Table 9 – Plant Fungal Pathogens – High risk categorized by genus level

Fungus Genus	**Species include, but not limited to**
Alternaria	Alternaria alternata
Botrytis	Botrytis cinerea
Blumeria	Blumeria graminis
Cercospora	Cercospora beticola, Cercospora kikuchii, Cercospora sojina
Corynespora	Corynespora cassiicola
Dydimella	Dydimella bryoniae
Mycosphaerella	Mycosphaerella fijiensis, Mycosphaerella brassicicola, Mycosphaerella musicola, Mycosphaerella nawae, Mycosphaerella pinodes
Phakopsora	Phakopsora pachyrhizi
Plasmopara	Plasmopara viticola
Pseudoperonospora	Pseudoperonospora cubensis
Pseudocercospora	Pseudocercospora (Mycosphaerella) fijiensis
Pyricularia	Pyricularia oryzae
Ramularia	Ramularia collo-cygni
Sphaerotheca	Sphaerotheca fuliginea, Podosphaera xanthii
Venturia	All Venturia included
Zymoseptoria	Zymoseptoria tritici; Synonymous with Septoria

Table 10 – Plant Fungal Pathogens – Medium risk categorized as one group and includes following genus level

Fungus Genus	**Species include, but not limited to**
Albugo	Albugo candida
Alternaria	Alternaria brassicicola, A. brassicae, Alternaria solani
Ascochyta	Ascochyta pisi
Bipolaris	Bipolaris maydis
Blumeriella	Blumeriella jaapii
Bremia	Bremia lactucae
Colletotrichum	Colletotrichum acutatum, Colletotrichum gloeosporoides
Drepanopeziza	Drepanopeziza ribis
Elsinoe	Elsinoe spp.
Erysiphe	Erysiphe cruciferarum, Erysiphe heraclei, Erysiphe necator
Gibberella	Gibberella fujikuori
Glomerella	Glomerella cingulata (anamorph: Gloeosporium fructigenum)
Neofabraea (anamorph Gloeosprorium)	Neofabraea malicorticis, Neofabraea perennans, Neofabraea vagabunda
Leveillula	Leveillula taurica
Monographella	Monographella nivale
Monilinia	Monilinia spp.
Mycovellosiella	Mycovellosiella nattrassii
Oculimacula	Oculimacula spp.
Oidium	Oidium neolycopersici
Penicillium	Penicillium digitatum, Penicillium expansum
Peronospora	Peronospora spp., Peronospora manshurica
Pestalotiopsis	Pestalotiopsis longiseta
Phyllosticta	Phyllosticta citricarpa
Phytophthora	Phytophthora capsici, Phytophthora infestans, Phytophthora porri
Pseudoperonospora	Pseudoperonospora humuli
Pyrenopeziza	Pyrenopeziza brassicae, Pyrenophora teres, Pyrenophora tritici-repentis
Ramularia	Ramularia areola
Sclerotinia	Sclerotinia homoeocarpa
Septoria	Septoria glycines, Septoria lycopersici
Setosphaeria	Setosphaeria turcica
Sphaerotheca	Sphaerotheca macularis, Sphaerotheca mors-uvae
Spilocea	Spilocea oleagina
Stemphylium	Stemphylium vesicarium
Wilsonomyces	Wilsonomyces carpophilus (Ascospora beijerinckii)

Section E: List of Infectious Agents relevant for AMR R&D in the Environment

Categorization and inclusion methodology for environment pathogens relevant to AMR

All pathogens listed in the tables 1-10 above were included. For the categorization process, only pathogen genus or family level were used and are displayed in the Dynamic Dashboard following the approaches described under the sectors human, animal and plant.

References

1. Tacconelli, E., et al., Global priority list of antibiotic resistant bacteria to guide research, discovery, and development of new antibiotics. World Health Organisation, 2017. 27.
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3. European Centre for Disease Prevention and Control. European Antimicrobial Resistance Surveillance Network (EARS-Net), Data collection and analysis. [cited 2019 1 October]; Available from: https://www.ecdc.europa.eu/en/about-us/partnerships-and-networks/disease-and-laboratory-networks/ears-net
4. Indian Priority Pathogen List to guide research, discovery and development of new antibiotics in India, March 2021. Available from: http://dbtindia.gov.in/sites/default/files/IPPL_final.pdf [accessed 28.4.2021]