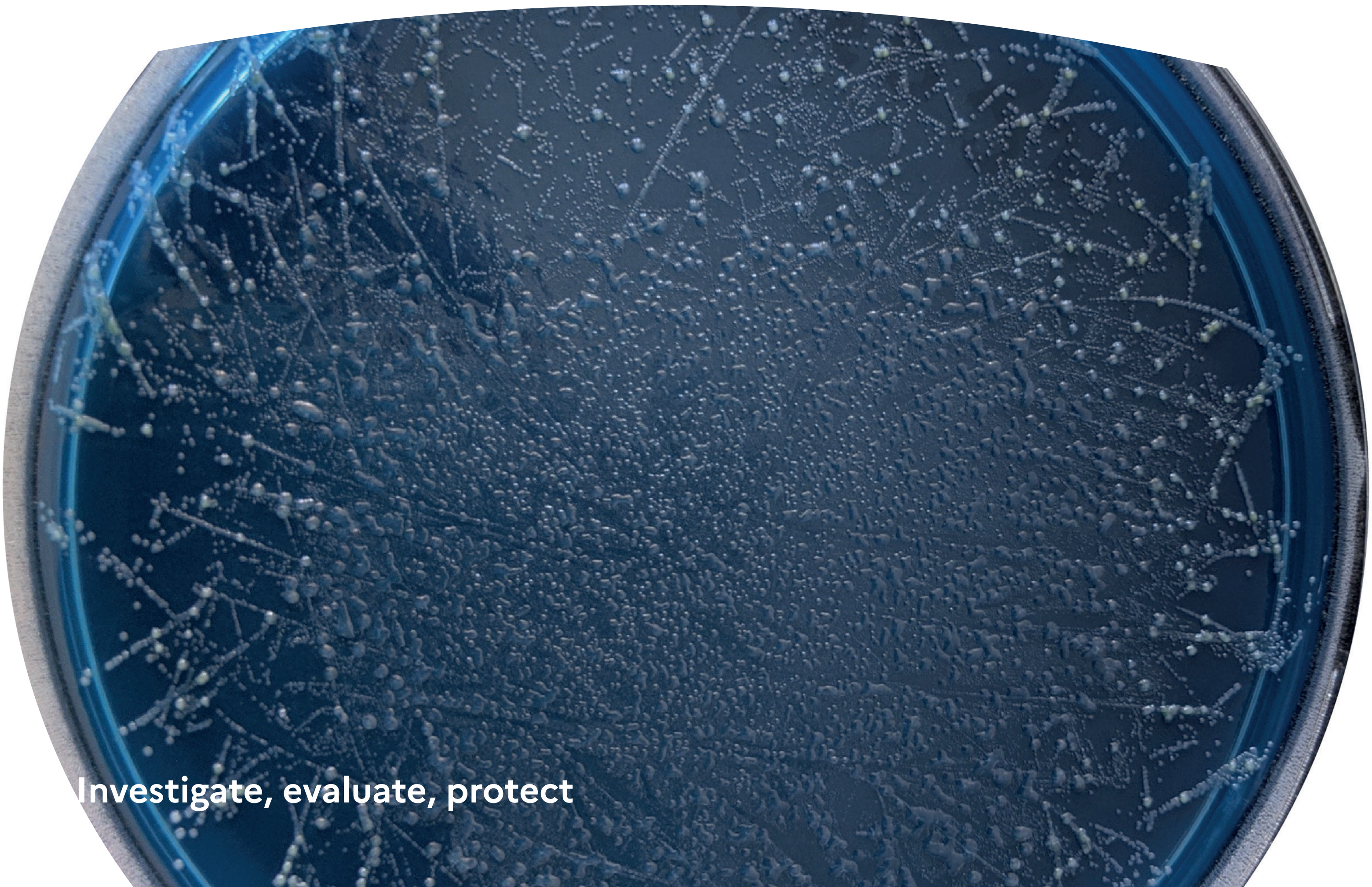
Resapath

French surveillance network for antimicrobial resistance in bacteria from diseased animals

2022 Annual report

November 2023



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https://shiny-public.anses.fr/ENresapath2/ (English version)

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Antimicrobial resistance, antibiotics, bacteria, network, surveillance, animal

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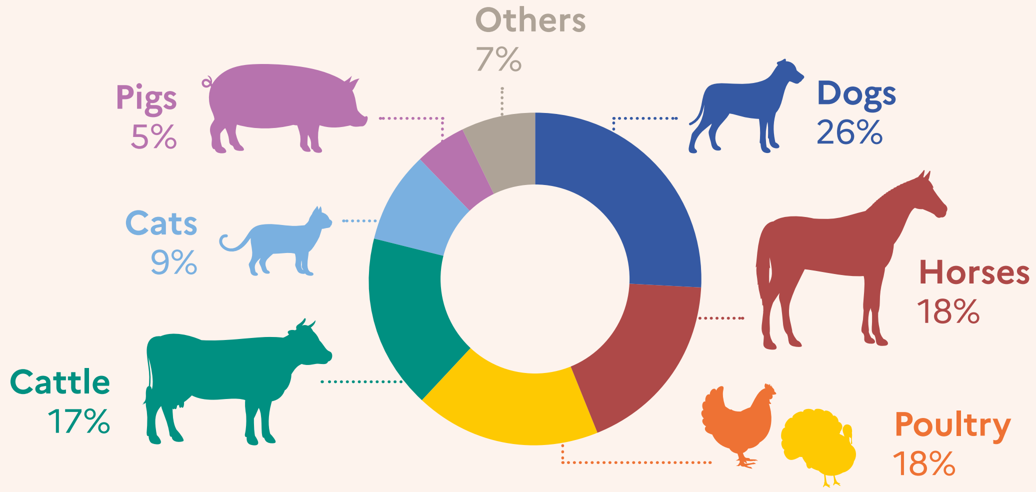
RESAPATH – HIGHLIGHTS 2022

108
CONTRIBUTING LABORATORIES

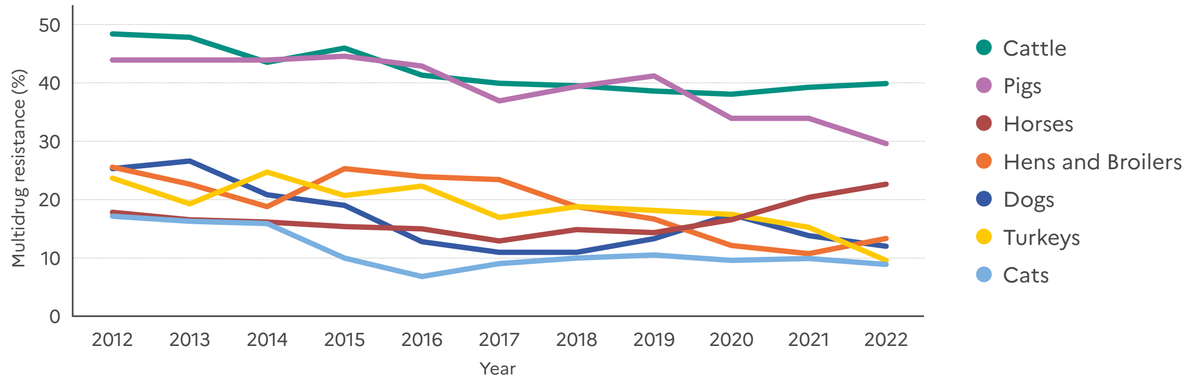
70,606
ANTIBIOGRAMS COLLECTED

DISTRIBUTION OF ANTIBIOGRAMS COLLECTED



MULTIDRUG-RESISTANCE *(E. coli)*

Acquired resistance (I or R phenotype) to at least three antibiotics from a panel of five tested (amoxicillin, gentamicin, tetracycline, trimethoprim-sulfonamides, nalidixic acid)



- Significant increase in multidrug-resistance in horses (+10% since 2017).
- Significant decrease (-8% to -14%) for all other animal species since 2012.

RESISTANCE ACCORDING TO ANTIBIOTICS

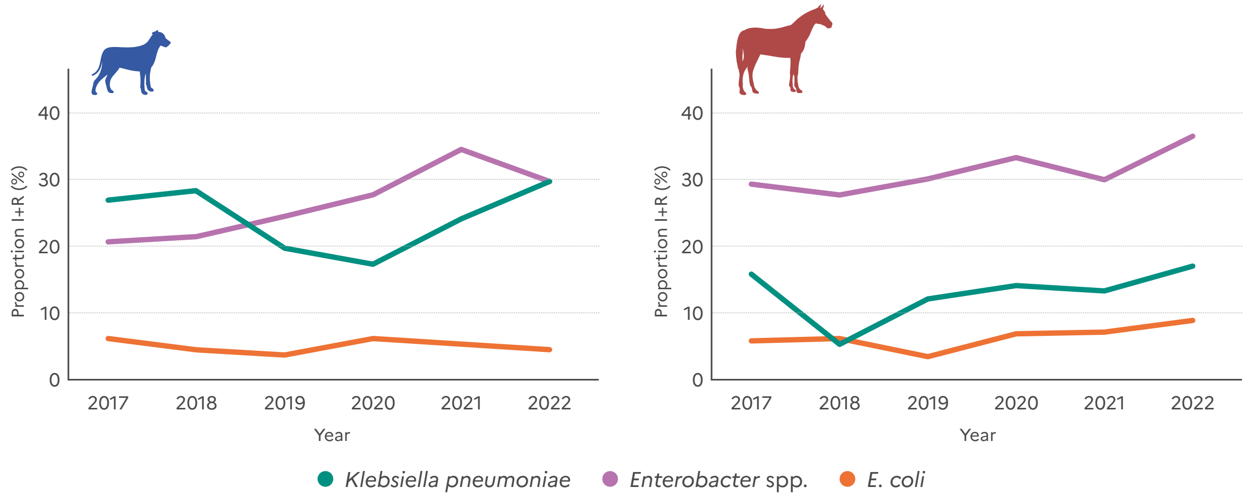
CRITICALLY IMPORTANT ANTIBIOTICS

Ceftiofur (3CG) and fluoroquinolones *(E. coli)*

- Low proportions of resistant strains over the past 5 years for most of animal species (<5-7%)..
- Increase in proportions of resistance over the past 4 years for horses (9% in 2022).

Ceftiofur (3CG) for other *Enterobacterales*

- In dogs and horses, resistance is lower for *E. coli* than for *Klebsiella pneumoniae* or *Enterobacter* spp.



METHICILLIN

- Estimated proportion in *Staphylococcus aureus* (MRSA): 5-10% in dogs/cats, 15-20% in horses, 42% in pigs.
- Frequent resistance (15-20%) in *Staphylococcus pseudintermedius* (dogs, cats).

CARBAPENEMS

- Regular isolation of *K. pneumoniae* and to a lesser extent of *E. coli* carrying the $bla_{OXA\text{-}48}$ resistance gene in dogs and cats.

AMOXICILLIN WITH OR WITHOUT CLAVULANIC ACID *(E. coli)*

- Increase since 2018 in all animal species, with the exception of turkeys for amoxicillin (stability). This increase is mainly due to *E. coli* categorized as intermediate.

OTHER ANTIBIOTICS *(E. coli)*

- Resistance generally stable or decreasing in all animal species, except horses (increase since 2018).
- Notable decrease over the past 10 years for tetracycline and quinolones in livestock species (pigs, poultry and cattle).
- Colistin: stable and low proportions over the past 5 years (< 10% in pigs and cattle, < 4% in turkeys and < 2% in hens and broilers).

Data available on **RESAPATH on line**.

November 2023

Abbreviations

Abbreviation	Definition
3GC/4GC	Third- and fourth-generation cephalosporins
AFNOR	French organisation for standardisation
AMR	Antimicrobial resistance
ANSES	French Agency for Food, Environmental and Occupational Health & Safety
AST	Antimicrobial susceptibility testing
CA-SFM	Committee of the French Society of Microbiology – Antibiogram Committee
CIA	critically-important antibiotics
CoNS	Coagulase negative staphylococci
CoPS	Coagulase positive staphylococci
EARS-Vet	European Antimicrobial Resistance Surveillance network in Veterinary medicine
EFSA	European Food Safety Authority
EQA	External quality assessment
ESBL	Extended-spectrum beta-lactamase
EUCAST	European Committee on Antimicrobial Susceptibility Testing
EU-JAMRAI	European Joint Action on Antimicrobial Resistance and healthcare Associated Infections
FAO	Food and Agriculture Organization of the United Nations
FQ	Fluoroquinolones
IT	Information technology
JPI-AMR	Joint Programming Initiative on Antimicrobial Resistance
MDR	Multidrug resistance
MLS_B	Macrolides-Lincosamides-Streptogramins B
MRSA	Methicillin-resistant *Staphylococcus aureus*
MRSP	Methicillin-resistant *Staphylococcus pseudintermedius*
ONERBA	French National Observatory for Epidemiology of Bacterial Resistance to Antimicrobials
PRR	National Priority Research Programme on AMR
Resapath	French surveillance network for antimicrobial resistance in bacteria from diseased animals
SSTI	Skin and soft tissue infections
EU	European Union
UTI	Urinary tract infections
WHO	World Health Organization

Editorial

Created in 1982, the **Resapath network** has been contributing to the monitoring of antimicrobial resistance (AMR) in animal pathogenic bacteria in France for more than 40 years.

Set up first for the bovine sector (Resabo), then progressively extended to all other animal species, Resapath collects antibiograms data produced annually by the member laboratories in France and analyses AMR trends, thereby contributing to assess the efficiency of the National Action Plan Ecoantibio.

Resapath interfaces animal data with those available in other sectors in a **One Health approach**, in particular within the frame of the Interministerial Roadmap. Also, beyond resistance phenotypes, genomic analyses conducted by Resapath contribute to a better understanding of crossed issues in the three sectors: Human, animal and the environment.

Finally, Resapath promotes AMR monitoring in diseased animals **beyond national borders**, by coordinating the European network EARS-Vet set up during the EU-JAMRAI 1 joint action (2017-2021), and to be fully developed through the upcoming EU-JAMRAI 2 joint action (2023-2027).

The Resapath report presents useful raw data (available online at https://shiny-public.anses.fr/ENresapath2/) but also several in-depth analyses on AMR in diseased animals in France.

Thanks to all contributors and enjoy reading!

The Resapath Team

Part 1

About the Resapath

Context

Resapath objectives

The Resapath is the French network for surveillance of antimicrobial resistance (AMR) in bacteria from diseased animals. Launched in 1982 for the study of AMR in cattle, it has over time extended its scope and consolidated its legitimacy for surveillance of AMR in pigs and poultry (2001), as well as dogs, cats and horses (2007).

More specifically, the main objectives of Resapath are as follows:

- To monitor AMR in bacteria isolated from diseased animals in France,
- To provide member laboratories with scientific and technical support on antimicrobial susceptibility testing methods and result interpretation,
- To detect the emergence of new resistances and their dissemination within bacteria of animal origin,
- To contribute to the characterization of the molecular mechanisms responsible for resistance.

French and European context

The Resapath complements the data collected by other French surveillance programmes in animals, including the European AMR surveillance programme in commensal and zoonotic bacteria[1] from food-producing animals at slaughterhouse and food thereof, and the monitoring of sales and deliveries of antimicrobials for veterinary use[2] *(Figure 1).* All these data contribute to the development, the implementation and the evaluation of intervention measures for the control of AMR in animals, including those that are part of the National Action Plans EcoAntibio 1 (2012-2016) and EcoAntibio 2 (2017-2022), as well as the Interministerial roadmap for the control of AMR (2016).

Resapath also opens up many opportunities for molecular and genomic surveillance by setting up a large collection of animal bacterial strains of interest. Beyond characterization of phenotypical trends of AMR, molecular studies are performed in parallel of the National Reference Centres, allowing to compare bacteria, clones or mechanisms of resistance between humans and animals. These comparisons are critical to better understand which hazards are common across sectors and which are not, which is an important aspect to support targeted and effective decision-making.

Acknowledging the importance of the One Health approach, Resapath is also a partner of the national meta-network of professional actors engaged against AMR (PROMISE), as well as the national platform of AMR multi-omics databases (ABRomics-PF)[3]. Those two networks were launched in 2021 as part of the National Priority Research Programme on AMR (PPR) and will contribute to support and coordinate AMR surveillance and research at the human-animal-environment interface.

Lastly, Resapath works in close collaboration with its European and international counterparts. While AMR surveillance in animal pathogens is still not regulated nor harmonized in Europe so far, the Resapath currently coordinates, in collaboration with 12 European countries and several EU bodies, an initiative that aims to develop a European AMR surveillance network in veterinary medicine (EARS-Vet)[4].

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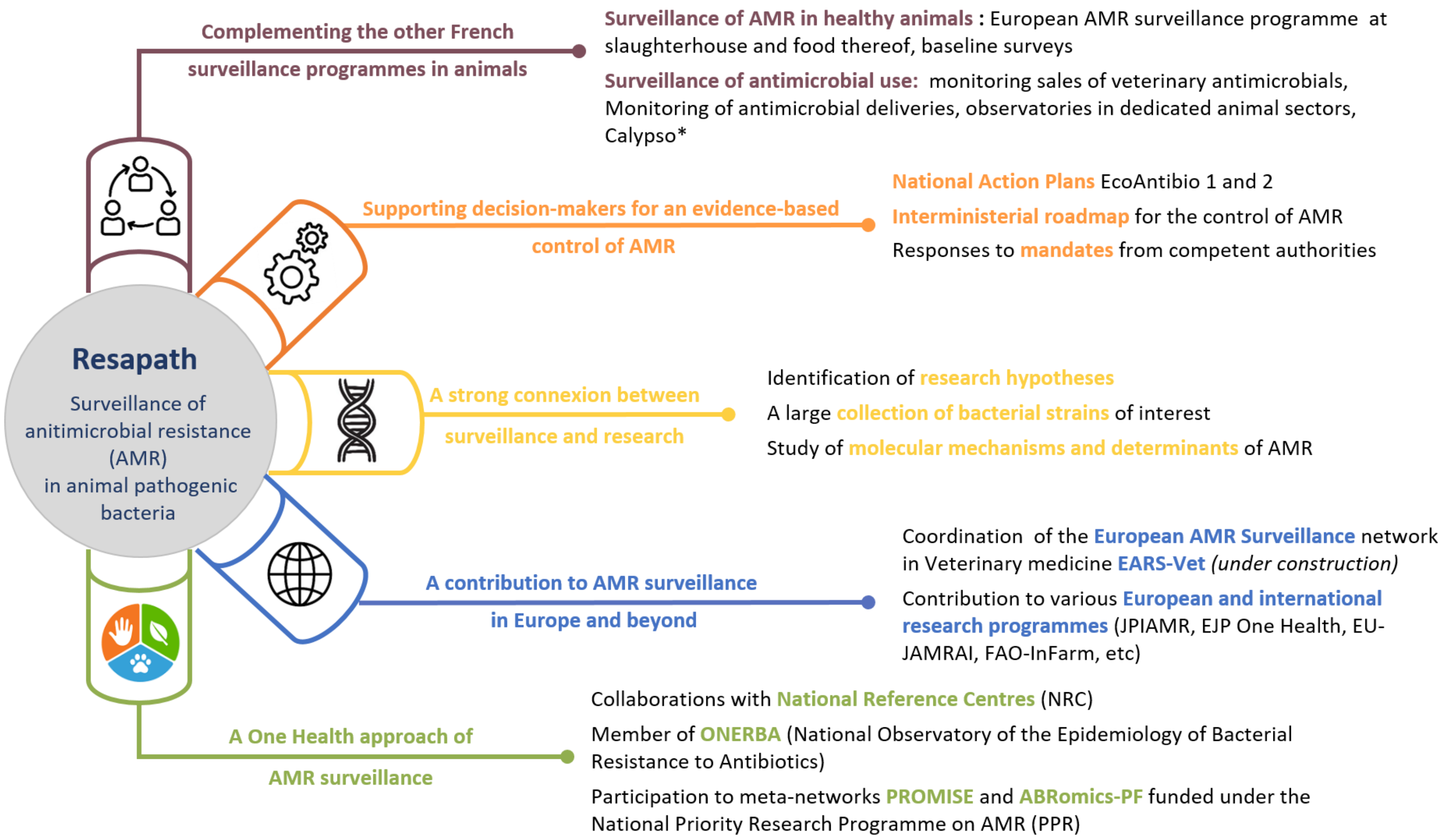
[1] https://multimedia.efsa.europa.eu/dataviz-2021/index.htm

[2] ANSES 2022. Sales survey of veterinary medicinal products containing antimicrobials in France in 2021, Anses-ANMV, France, November 2022, report, 96 pp. https://www.anses.fr/en/system/files/ANMV-Ra-Antibiotiques2021-GB.pdf

[3] https://ppr-antibioresistance.inserm.fr/fr

[4] Mader R, Damborg P, Amat J-P, et al. (2021). Building the European Antimicrobial Resistance Surveillance network in veterinary medicine (EARS-Vet). *Eurosurveillance*, 26(4), 2001359.

Figure 1. Contributions of Resapath to AMR surveillance in France and beyond



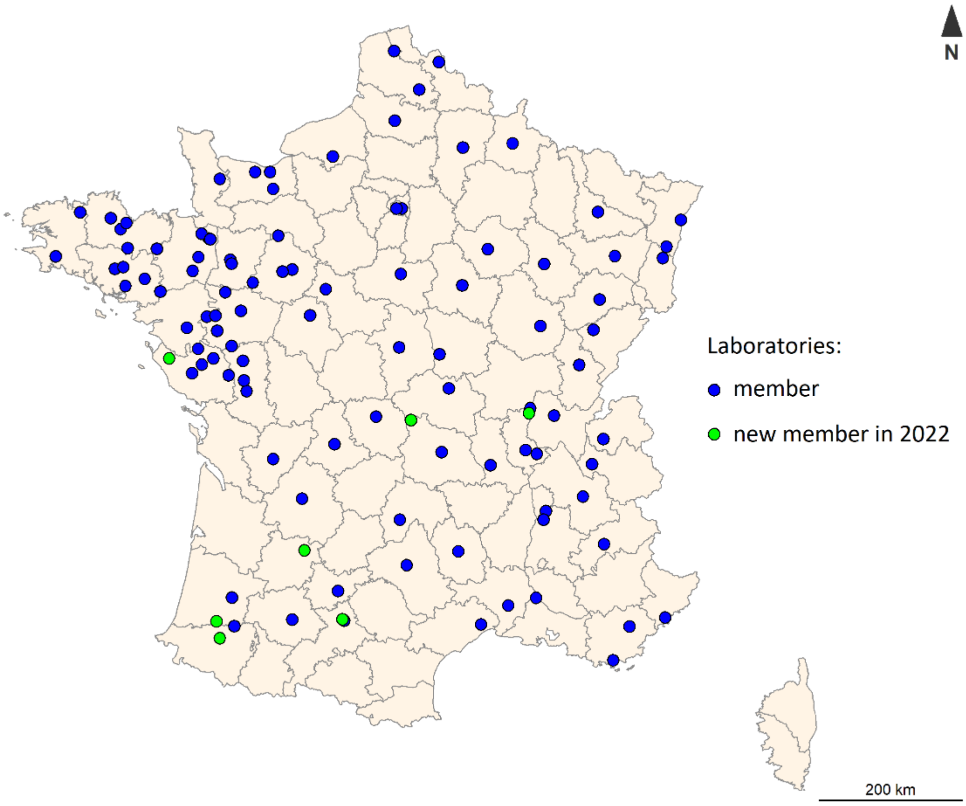
* *Calypso is an information system launched in 2023, facilitating health data to be exchanged between veterinarians, national authorities and other relevant stakeholders, including data on the prescription and deliveries of antimicrobials*

Network functioning and operations

Member laboratories

Resapath performs passive and phenotypical AMR surveillance. Coordinated by the French Agency for Food, Environmental and Occupational Health & Safety (ANSES), it brings together a large number of veterinary diagnostic laboratories in France (public or private).
The network had 108 contributing laboratories in 2022 spread over the metropolitan territory *(Appendix 1)*. Major developments in the data management IT system have enabled the addition of 26 new member laboratories in 2021 and 7 in 2022 *(Figure 2)*.

Figure 2. Laboratories participating to Resapath in 2022



Steering committee

Resapath is supervised by a steering committee that meets once a year *(Figure 3)*. It is composed of representatives of diagnostic laboratories, veterinary practitioners, representatives of human medicine, the General Directorate for Food and ANSES (including both Laboratories and the Agency for Veterinary Medicinal Products).

Figure 3. Resapath actors

Collected data

The member laboratories, which are all volunteers, send to Resapath the results of antimicrobial susceptibility testing (antibiograms) carried out at the request of veterinary practitioners as part of their animal care activity.

For each antibiogram carried out in a member laboratory, Resapath collects data on the bacteria identified, the antibiotics tested, the inhibition zone diameters and the date of the analysis. Other epidemiological data are also collected (i.e. animal species, age category, pathology, type of sample and geographical location). Some data may be missing when they have not been transmitted by the veterinarian or by the laboratory. The network's operations and the quality of the data collected are assessed each year by calculating performance indicators (PI) *(Appendix 2).*

Susceptibility testing method

Antibiograms are performed by disk diffusion according to the recommendations from the veterinary section of the Antibiogram Committee of the French Society of Microbiology (CA-SFM) and the AFNOR NF U47-107 standards. Laboratories contributing to Resapath participate to an annual ring trial (Inter-laboratory proficiency testing). In addition, annual training sessions, technical support, on-site training and other training activities are also provided to the Resapath laboratories, as part of a continuous improvement process.

Standards and interpretation

From the inhibition zones diameters transmitted by the laboratories, Resapath categorizes bacteria strains as susceptible (S), intermediate (I) or resistant (R) according to the CA-SFM recommendations.[5,6] Should no established breakpoints be available, cut-off values provided by the antibiotic manufacturer are used.

The antibiotics tested by the Resapath laboratories are primarily those prescribed in veterinary medicine. To help characterize certain resistance profiles of major interest (e.g. extended spectrum beta-lactamase (ESBL)-producing Enterobacterales or methicillin-resistant *Staphylococcus aureus* (MRSA)), other antibiotics may also be tested (e.g. cefoxitin), which in no way reflects veterinary use of these antibiotics.

Collection of bacterial strains and molecular analyses

ANSES collects, via the Resapath, certain isolates whose AMR profile is of interest to be characterized at a molecular level. In-depth characterization of the molecular mechanisms involved makes it possible to more precisely document the evolutions and emergences observed in the field. Other strains are collected to document the distributions of inhibition zones diameters for certain bacteria / antibiotic combinations and contribute to update the interpretation criteria.

5 Antibiogram committee – French society of microbiology - https://www.sfm-microbiologie.org

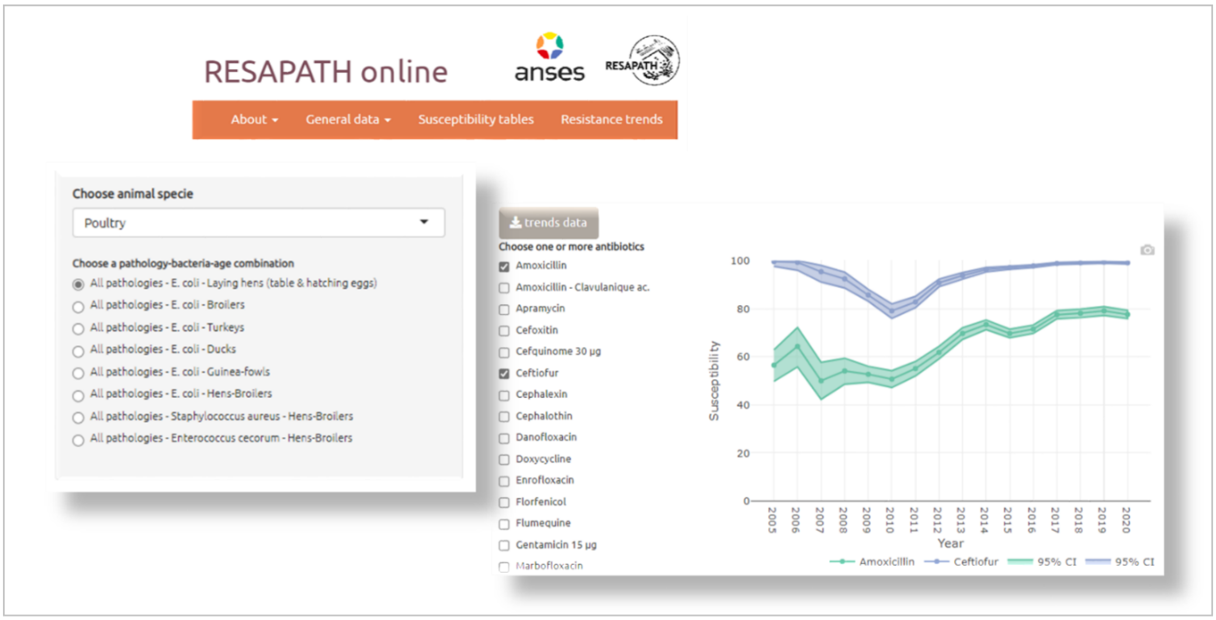
6 The human version of the CA-SFM used here dates back from 2013. Since 2014, recommendations of the European standard EUCAST (www.eucast.org) were included to the CA-SFM, leading to methodological changes (incubation at 35°C and higher inoculum). Resapath decided not to use the CA-SFM/EUCAST version because of the paucity of veterinary molecules included, and is waiting for VetCast (veterinary European standards, now under development) to be launched

Data access

Resapath data are freely accessible via an interactive open-access dashboard:

RESAPATH online (https://shiny-public.anses.fr/ENresapath2/)

Figure 4. Screenshot from the Resapath open-access dashboard (RESAPATH online)



This dashboard *(Figure 4)* allows the visualization of data collected by Resapath, by selecting different combinations of interest (year/animal species/bacteria/pathology/antibiotic). Data are presented through four tabs:

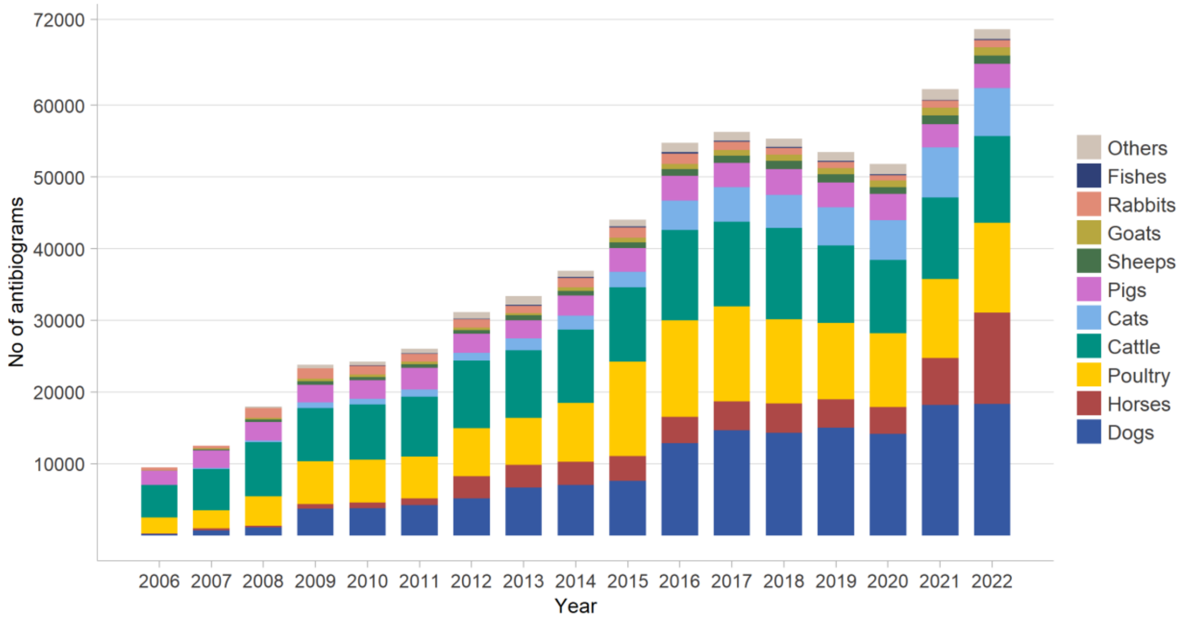
- General data: number of antibiotic susceptibility tests performed;
- Antimicrobial resistance tables: proportion of resistant strains;
- Trends: temporal trends in the proportions of resistance strains with their 95% confidence intervals.
- Resistance mapping: proportions of resistant strains by French department.

All graphs are downloadable as images along with their associated data in Excel® format.

Key figures

- **70,706 antibiograms collected in 2022**

Figure 5. Annual number of antibiograms collected per animal sector



- **Antibiograms per animal categories in 2022**

***Tableau** 1. Number of antibiograms collected per animal categories in 2022*

Animal species	No of antibiograms	%
Dogs	18,329	26.0
Horses	12,761	18.1
Poultry	12,489	17.7
Cattle	12,132	17.2
Cats	6,685	9.5
Pigs	3,417	4.8
Others*	1,390	2.0
Sheep	1,163	1.7
Goat	1,134	1.6
Rabbits	987	1.4
Fish	117	0.2
Total	70,604	100.0

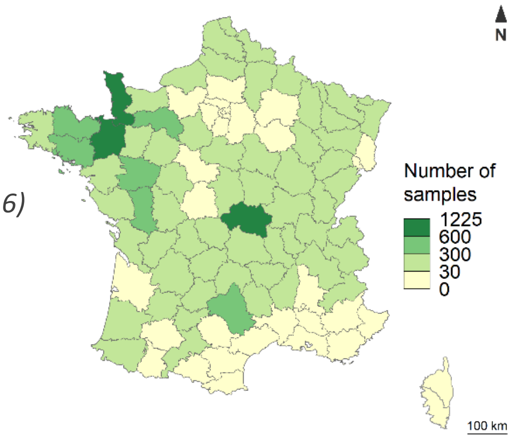
** Birds, pet rodents, aquarium fish, monkeys, snakes...*

Part 2

Results
by animal categories

CATTLE

Figure 6. *Origin of cattle samples*



COLLECTED DATA

- 12,132 antibiograms
- 93 contributing laboratories
- Samples from 87 departments (local administrative unit) *(Figure 6)*
- Adults (40%), calves (42%), unknown age (18%)

Adults

- Main disease:
  - Mastitis (92%)
- Main bacteria:
  - *Escherichia coli* (33%)
  - *Streptococcus* spp. (27%)
  - CoNS (10%)
  - CoPS (6%)

Calves

- Main diseases:
  - Digestive (81%)
  - Respiratory (11%)
- Main bacteria:
  - *Escherichia coli* (84%)
  - *Pasteurella* spp. (5%)
  - *Mannheimia* spp. (3%)
  - *Salmonella* spp. (2%)

RESISTANCE DATA

Escherichia coli

- Isolates of digestive origin (neonatal gastroenteritis) are the most frequently resistant ones.
- Resistances are mostly found to amoxicillin, streptomycin and sulfonamides (83-87%).
- Resistance to amoxicillin is increasing in mastitis isolates (+7% in 2022). Resistance to amoxicillin-clavulanic acid remains stable.
- Resistance to 3GC/4GC (2%) and fluoroquinolones (8%) remains very low (see dedicated focus).

Pasteurella spp.

- Bovine *Pasteurella* spp. remain largely susceptible to all beta-lactams.
- Resistance to streptomycin is frequent (73%), but a decrease was observed in 2022 (-6%).

Staphylococcus spp.

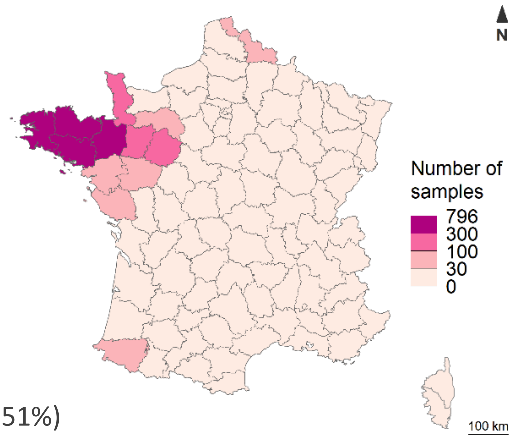
- The majority of staphylococci (CoPS or CoNS) comes from mastitis (88-93%).
- The most frequent resistance phenotype is to penicillin G (17% in CoPS and 27% in CoNS).
- A slight increase in the number of MRSA isolates was observed (8%, +3% compared to 2021).

Streptococcus spp.

- Resistance to gentamicin remains low in *S. uberis* (2%), while penicillin-resistance is nearly absent.
- A slight decrease in resistance to erythromycin and lincosamides (constitutive or inducible MLSb phenotype) was observed in *S. uberis* and *S. dysgalactiae* (-5% and -2%, respectively).

PIGS

Figure 7. Origin of pig samples



COLLECTED DATA

- 3,417 antibiograms
- 59 contributing laboratories
- Samples from 77 departments (including 4 which represent 63% of the data) *(Figure 7)*
- Piglets (58%), sows (13%), unknown age (29%)

- Main diseases:
  - Digestive (41%), mainly in piglets
  - Septicemia (12%)
  - Respiratory (10%)

- Main bacteria:
  - *Escherichia coli* (51%)
  - *Streptococcus suis* (17%)
  - *Actinobacillus pleuropneumoniae* (5%)
  - *Enterococcus hirae* (4%)
  - *Glaesserella parasuis* (3%)
  - *Pasteurella multocida* (3%)

RESISTANCE DATA

Escherichia coli

- 59% of isolates are resistant to amoxicillin, but less than 1% to ceftiofur.
- 16% of isolates are resistant to nalidixic acid and 2% to fluoroquinolones.
- Between 5% and 6% of isolates are resistant to apramycin or gentamicin.
- 40% of isolates are resistant to the trimethoprim-sulfamethoxazole combination, and 56% to tetracycline.
- Less than 5% of isolates are resistant to colistin.

Pasteurella multocida, Actinobacillus pleuropneumoniae and Glaesserella parasuis

- Less than 5% of isolates are resistant to amoxicillin.
- Less than 2% of isolates are resistant to ceftiofur, to florfenicol or to fluoroquinolones.

Streptococcus suis

- Resistance to amoxicillin is very rare (< 1%) and 5% of isolates are resistant to oxacillin (marker of penicillin G).
- High-level resistance to aminoglycosides is scarce (synergy with beta-lactams is preserved).

Staphylococcus aureus

- Among CoPS, 52 *S. aureus* of which 42% resist to cefoxitin, indicating a suspicion of MRSA.

Enterococcus hirae

- Resistance to amoxicillin concerns 8% of isolates.
- 82% are resistant to erythromycin and almost all to lincomycin (99%).

POULTRY

COLLECTED DATA

- 12,489 antibiograms
- 90 contributing laboratories
- Samples from 89 departments *(Figure 8)*
- Poultry species:

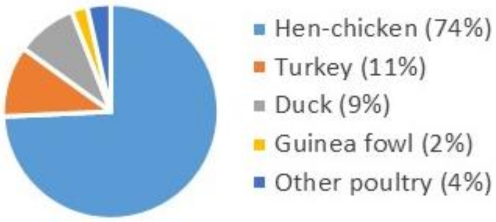
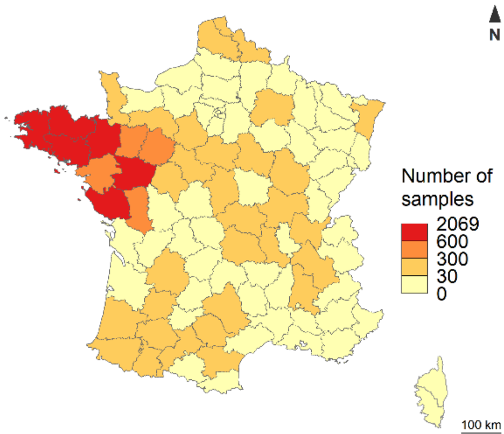


Figure 8. Origin of poultry samples



- Main diseases:
  - Septicemia (77%)
  - Arthritis (11%)
  - Respiratory (3%)

- Main bacteria:
  - *Escherichia coli* (74%)
  - *Enterococcus cecorum* (8%)
  - *Staphylococcus aureus* (4%)
  - *Enterococcus faecalis* (3%)
  - *Ornithobacterium rhinotracheale* (1%)
  - *Pasteurella multocida* (1%)

RESISTANCE DATA

Escherichia coli

In hens and broiler chickens, turkey, ducks and guinea fowls, depending on the species:

- 42% (turkeys) to 60% (guinea fowls) of isolates are resistant to amoxicillin, and less than 1% to ceftiofur.
- 2% to 4% of isolates are resistant to enrofloxacin for all poultry species.
- 1% (turkeys) to 8% (hens/broilers) are resistant to gentamicin.
- 25% (guinea fowls) to 40% (ducks) of isolates are resistant to tetracycline, and 13-15% to the trimethoprim- sulfamethoxazole combination for all four animal species.

Enterococcus cecorum (hens and broilers)

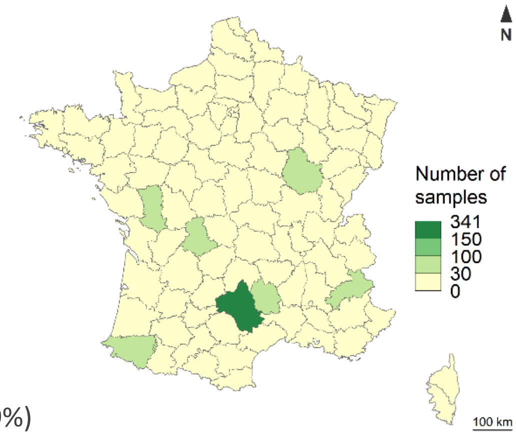
- Less than 1% of isolates are resistant to amoxicillin.
- A resistance proportion of 36% to macrolides-lincosamides.
- 67% of isolates are resistant to the trimethoprim-sulfamethoxazole combination, and 93% to tetracycline.

Staphylococcus aureus (hens and broilers)

- Between 1% and 8% of isolates are resistant to the most frequently tested antibiotics, with the exception of erythromycin, lincomycin, penicillin G and tetracycline (15% to 19%).
- 7% of isolates are resistant to cefoxitin, indicating a possible resistance to methicillin (MRSA).

SHEEP

Figure 9. Origin of sheep samples



COLLECTED DATA

- 1,163 antibiograms
- 80 laboratories (including 1 representing 34% of the data)
- Samples from 83 departments *(Figure 9)*
- Adults (18%), young (52%), unknown age (30%)

Adults

- Main diseases:
  - Mastitis (35%)
  - Respiratory (28%)
- Main bacteria :
  - *Mannheimia* spp. (19%)
  - CoPS (18%)
  - *Escherichia coli* (15%)
  - *Pasteurella* spp. (11%)

Lambs

- Main diseases:
  - Digestive (43%)
  - Respiratory (34%)
- Main bacteria :
  - *Escherichia coli* (55%)
  - *Mannheimia* spp. (21%)
  - *Pasteurella* spp. (10%)

RESISTANCE DATA

Escherichia coli

- *E. coli* isolates responsible for digestive tract infections in sheep present resistance proportions lower than those reported for bovine neonatal gastroenteritis.
- Resistances are frequently found to amoxicillin (55%), tetracyclines (55%) and amoxicillin-clavulanic acid (48%).
- Resistance to streptomycin is high (57%), while resistance to gentamicin is low (5%).
- Resistances to 3GC/4GC and fluoroquinolones remain very low (<2%).

Mannheimia haemolytica

- Data concerning *M. haemolytica*, all pathologies included, show no specific resistance of interest.

GOATS

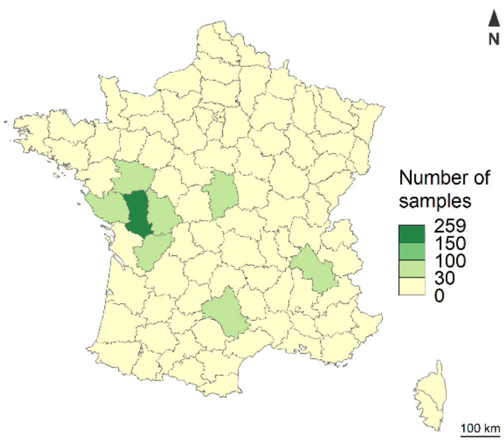


Figure 10. Origin of goat samples

COLLECTED DATA

- 1,134 antibiograms
- 75 laboratories
- Samples from 72 departments *(Figure 10)*
- Adults (34%), young (28%), unknown age (38%)

Adults

- Main diseases:
  - Mastitis (66%)
  - Respiratory (14%)
- Main bacteria:
  - *Escherichia coli* (20%)
  - CoPS (17%)
  - CoNS (16%)

Young

- Main diseases:
  - Digestive (44%)
  - Respiratory (23%)
- Main bacteria:
  - *Escherichia coli* (57%)
  - *Mannheimia* spp. (18%)
  - *Clostridium* spp. (5%)
  - *Klebsiella* spp. (4%)
  - *Pasteurella* spp. (4%)

RESISTANCE DATA

Escherichia coli

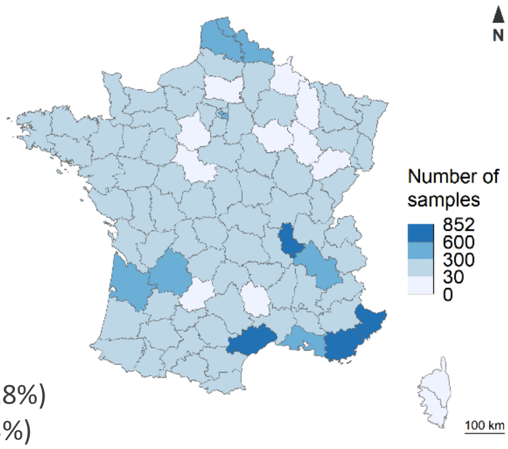
- Resistance to 3GC/4GC remains low (<3%).
- Resistance to enrofloxacin and marbofloxacin has increased (+7% between 2020 and 2022).
- High levels of resistance were reported for other antibiotics: tetracyclines (58%), amoxicillin (68%, +8% compared to 2021), and streptomycin (58%).

Pasteurella spp. and *Mannheimia* spp.

- No specific resistance phenotypes were observed for *Pasteurella* spp. and *Mannheimia* spp.

DOGS

Figure 11. *Origin of dog samples*



COLLECTED DATA

- 18,329 antibiograms
- 89 laboratories (including 3 representing 56% of the data)*
- Samples from 98 departments *(Figure 11)*
- Adults (54%), young (2%), unknown age (44%)

Adults

- Main diseases:
  - Otitis (35%)
  - Kidney/urinary tract infection (24%)
  - Skin and soft tissue infection (14%)
- Main bacteria:
  - CoPS (19%)
  - *Escherichia coli* (18%)
  - *Pseudomonas* (13%)
  - *Proteus* spp. (8%)

Young dogs

- Main diseases:
  - Kidney/urinary tract infection (28%)
  - Digestive (17%)
  - Respiratory (12%)
- Main bacteria:
  - *Escherichia coli* (37%)
  - CoPS (20%)
  - *Enterococcus* spp. (7%)
  - *Proteus* spp. (6%)

**Because of the frequency of referral cases in veterinary medicine, the location of the laboratory does not prejudge the geographical origin of the animals.*

RESISTANCE DATA

Escherichia coli

- Resistance to ceftiofur is stable in otitis and urinary tract infections (3-4% and 6-8% between 2019 and 2022, respectively) and decreasing in skin and soft tissue infections (16% in 2020; 4% in 2022).
- A gradual increase in resistance to amoxicillin (from 30% to 59%) and amoxicillin-clavulanic acid (from 26% to 43%) is observed since 5 years in isolates collected from urinary tract infections.

Proteus spp.

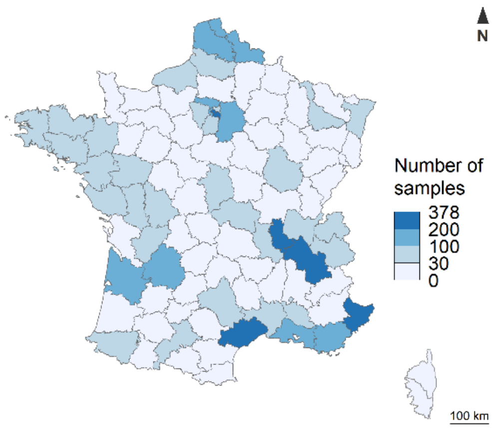
- A slight increase in resistance to 3GC (1% in 2021, 3% in 2022) remains to be monitored.
- Resistance to fluoroquinolones is decreasing (-6 to -7% for enrofloxacin and marbofloxacin).

Staphylococcus spp.

- About 75% of *S. aureus* isolates are resistant to penicillin G, and 20% have an MLSb phenotype.
- MRSA and MRSP represent 20% and 10% of *S. aureus* and *S. pseudintermedius* isolates, respectively.

CATS

Figure 12. Origin of cat samples



COLLECTED DATA

- 6,685 antibiograms
- 78 laboratories (including 3 representing 53% of the data)
- Samples from 95 departments *(Figure 12)*
- Adults (55%), young (4%), unknown age (41%)

- Main diseases:
  - Kidney/ urinary tract infection (39%)*
  - Otitis (13%)
  - Respiratory (12%)
  - Skin and soft tissue infection (6%)
  - Digestive (5%)*

- Main bacteria:
  - *Escherichia coli* (26%)
  - CoPS (13%)
  - *Pasteurella* spp. (11%)
  - CoNS (10%)
  - *Enterococcus* spp. (9%)

**When the age of the animals was specified, most of the samples from urinary tract infections originated from adults (98%), whereas samples from digestive tract infections were mostly from young animals (71%).*

RESISTANCE DATA

Escherichia coli

- Resistance to critically important antibiotics (CIA) remains low and stable (4% for both 3GC and fluoroquinolones).
- Resistance to amoxicillin and amoxicillin - clavulanic acid is still on an increasing trend (respectively +6% and +3% between 2021 and 2022).

Staphylococcus spp.

- CoPS isolates are frequently resistant to penicillin G (55%) for all pathologies considered.
- MRSA are identified in 14% of isolates from UTI and SSTI, and in 7% of isolates from otitis.

Pasteurella spp.

- Resistances to amoxicillin and amoxicillin-clavulanic acid were identified in 12% and 6% of isolates, respectively.
- 8% of isolates are resistant to tetracyclines.
- Resistance to ceftiofur and florfenicol are nearly absent (0-1%).

HORSES

COLLECTED DATA

- 12,761 antibiograms
- 59 laboratories (including one representing 72% of the data)
- Samples from 96 departments*
- Adults (16%), young (1%), unknown age (83%)

- Main diseases**:
  - Respiratory (30%)
  - Reproduction (22%)
  - Ocular (5%)
  - Skin and soft tissue infection (5%)

- Main bacteria :
  - *Streptococcus* spp. (26%)
  - *Escherichia coli* (12%)
  - CoPS (8%) *ou* CoNS (9%)
  - *Pseudomonas* spp. (7%)

* *The department of origin is unknown for 72% of the samples, hence the map displaying the departments of origin could not be produced.*
** *The pathology is unknown for 33% of the samples.*

RESISTANCE DATA

Escherichia coli

- Resistance to ceftiofur reaches 9%, all pathologies included.
- Resistance to amoxicillin (55%) and amoxicillin - clavulanic acid (43%) is still on an increasing trend when all pathologies are considered, but is now stable in infections of the reproductive tract.
- Resistance to amikacin is emerging (6%) in reproductive tract infections.

Enterobacterales

- Resistance to ceftiofur is increasing in *Enterobacter* spp. (30% in 2021, 37% in 2022) and *Klebsiella pneumoniae* (12% in 2021, 17% in 2022).
- Resistance to amikacin is emerging (6%) in *Enterobacter* spp.

Staphylococcus aureus

- Resistance to penicillin G (28%) and tetracycline (13%) are now stable after two years of decrease.
- MRSA are found in 17% of the isolates.

Streptococcus spp.

- *Streptococcus* spp. isolates are mostly susceptible to all antibiotics tested.
- The most frequent resistance phenotypes are to tetracycline and trimethoprim-sulfamethoxazole.
- Resistances to beta-lactams and aminoglycosides are very rare (hence, synergy is preserved).

RABBITS

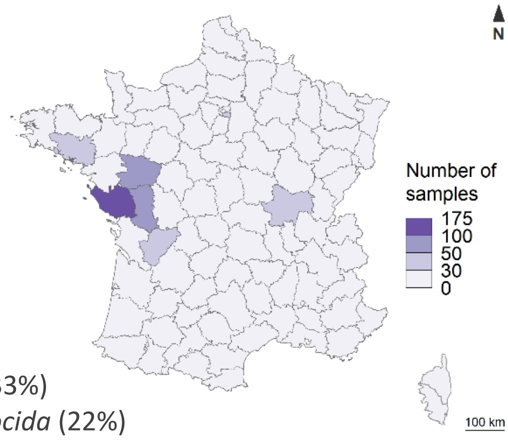


Figure 13. Origin of rabbit samples

COLLECTED DATA

- 987 antibiograms (mainly food producing rabbits)
- 74 laboratories
- Samples from 71 departments *(Figure 13)*

- Main diseases:
  - Respiratory (29%)
  - Digestive (21%)
  - Septicemia (16%)
  - Skin and soft tissue infection (13%)
- Main bacteria:
  - *Escherichia coli* (33%)
  - *Pasteurella multocida* (22%)
  - CoPS (12%)
  - CoNS (5%)
  - *Bordetella bronchiseptica* (4%)

RESISTANCE DATA

Escherichia coli

- The most frequent resistances are to tetracycline (83%), amoxicillin (71%, even though not used in rabbits) and trimethoprim-sulfamethoxazole (62%).
- Resistance to ceftiofur is rare (<1%).
- 17% of isolates are resistant to flumequine, and 2% to enrofloxacin.
- Resistance to apramycin or gentamicin reaches 9%.
- Resistance to colistin is found in about 10% of the isolates.

Pasteurella multocida

- Less than 8% of the isolates are resistant to the most frequently tested antibiotics, except nalidixic acid (39%) and flumequine (13%).

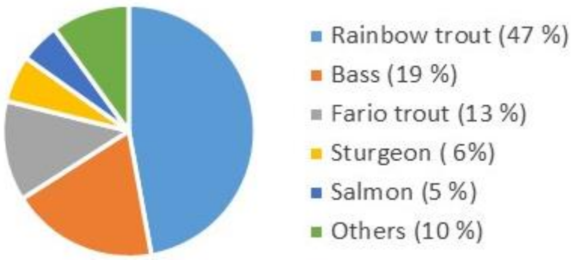
Staphylococcus aureus

- 26% of isolates are resistant to penicillin G.
- 4% of isolates are suspected of being MRSA (resistance to cefoxitin).
- Resistances to tetracycline and macrolides-lincosamides are found in 40-60% of isolates, while resistances to trimethoprim-sulfamethoxazole and gentamicin are found in 26-27% of isolates.
- 6% of isolates are resistant to enrofloxacin.

FISH

COLLECTED DATA

- 117 antibiograms
- 5 laboratories
- Samples from 7 departments (department unknown for 79% of the antibiograms)
- Mains fish species:



- Main diseases:
  - Septicemia (19%)
  - Skin and soft tissue infection (2%)
  - Unknown (79%)
- Main bacteria:
  - *Aeromonas* spp. (54%)
  - *Aeromonas salmonicida* (37%)
  - *Yersinia ruckeri* (20%)
  - *Vibrio* spp. (16%)

RESISTANCE DATA

The data collected do not currently allow for a detailed description of AMR results. This is due to the small number of collected data, as well as to the uncertainty in the representativeness and the methodology used to test certain bacteria such as *Aeromonas salmonicida*.



OTHER SPECIES

COLLECTED DATA

- 1,390 antibiograms
- 61 laboratories
- Samples from 86 departments

Samples come mainly from:
- Mammals (domestic rabbits, monkeys, dwarf rabbits, guinea pigs, etc.) (69%)
- Birds (17%)
- Reptiles (10%)
- Aquarium fish (2%)
- Amphibians (2%)

RESISTANCE DATA

Due to the low numbers of antibiograms collected for each animal species and the multiplicity of pathologies and bacterial species, the detailed results of resistance levels concerning these animal species are not displayed in this report.

Part 3

Focuses

E. coli - Resistance trends for extended-spectrum cephalosporins and fluoroquinolones

Extended-spectrum cephalosporins (ESC) and fluoroquinolones (FQ) are critically-important antibiotics (CIA) for human health, thus their use in veterinary medicine is regulated by law. Proportions of resistance to these two antibiotic classes are considered as major indicators in the evaluation of national action plans against AMR.

Method

Ceftiofur and cefquinome in food-producing animals and horses, and cefovecin in cats and dogs are the only three ESC molecules used in veterinary medicine.
ESC resistance (ESC-R) trends in *E. coli* have been estimated using values obtained for ceftiofur resistance. Despite slight differences with cefquinome or cefovecin resistances, most likely resulting from differences in cephalosporin-hydrolyzing enzymes, resistance to ceftiofur is considered a reasonable proxy for all ESC-R.

Moreover, trends in resistances to enrofloxacin and marbofloxacin were considered representative of trends in all FQ-R.

Figure 14. Evolution of proportions (%) of E. coli *isolates non-susceptible (R+I) to ceftiofur (2012-2022)*

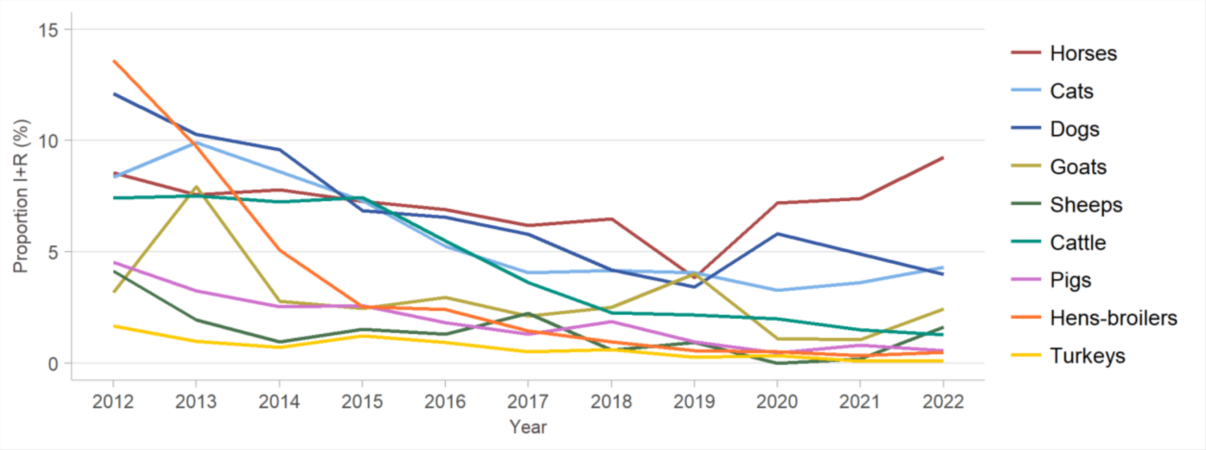


Figure 15. Evolution of proportions (%) of E. coli *isolates non-susceptible (R+I) to enrofloxacin or marbofloxacin (2012-2022)*

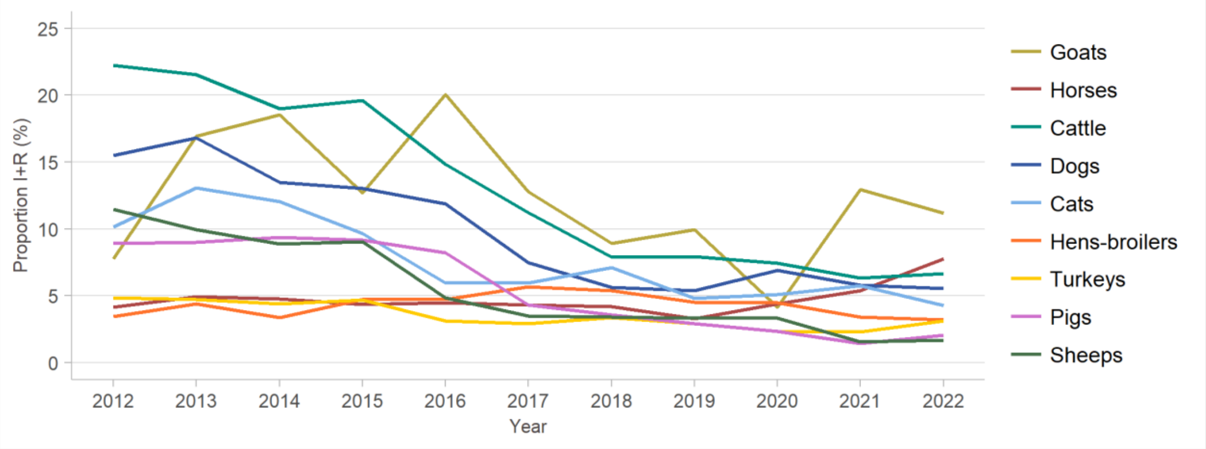
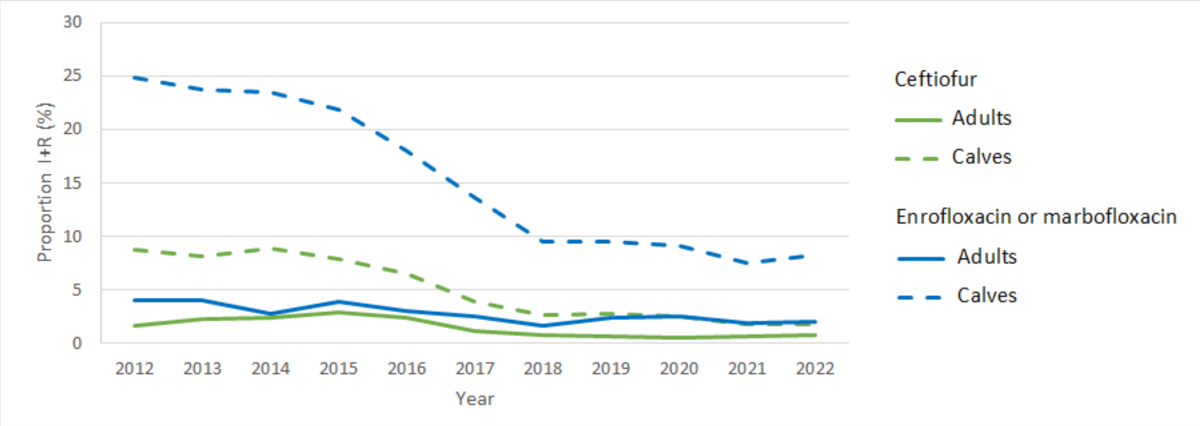


Figure 16. Evolution of proportions (%) of E. coli *isolates non-susceptible (R+I) to ceftiofur, to enrofloxacin or marbofloxacin, for cattle according to their age (2012-2022)*



- Data in 2022 confirm observations from previous years highlighting low ESC- and FQ-R rates in *E. coli* isolated from all animal categories *(Figures 14 and 15).*

- These trends reflect strong efforts from veterinarians to reduce antibiotic use and are consistent with a parallel substantial decrease in animal exposure to ESC and FQ[7]. In pigs and poultry, ESC- and FQ-R rates have been constantly low for several years. In cattle, a remarkable decrease in ESC- and FQ-R has been observed over the last years, although it is becoming more stable since 2018 *(Figures 14 and 15).*

- An increase in 3GC/4GC-R in horses (from 3.9 to 7.4% between 2019 and 2022) is noted and should be closely monitored. Of note, the increase in 3GC/4GC-R observed in dogs in 2020 did not progress.

- For a given animal category, ESC- and FQ-R rates strongly depend on animal age and pathology. For instance in cattle, ESC- and FQ-R is more frequent in young animals *(Figure 16).*

[7] ANSES 2022. Sales survey of veterinary medicinal products containing antimicrobials in France in 2021, Anses-ANMV, France, November 2022, report, 96 pp. https://www.anses.fr/en/system/files/ANMV-Ra-Antibiotiques2021-GB.pdf

Resistance to 3GC/4GC and fluoroquinolones in *K. pneumoniae* and *Enterobacter* spp.

Resistance to 3rd and 4th generation cephalosporins (3GC/4GC) and fluoroquinolones can concern all Enterobacterales, of which *Klebsiella pneumoniae* and *Enterobacter* spp. (including mainly *Enterobacter hormaechei*) are major pathogens in animals. The mechanisms involved are broadly similar between *E. coli*, *K. pneumoniae* and *Enterobacter* spp. In human medicine, the latter two bacteria are known to be highly resistant to 3GC/4GC and fluoroquinolones.

The methodology applied here is identical to the one described above for *E. coli*. Only data concerning horses and dogs were large enough to be analysed and compared with the proportions of resistance observed in *E. coli*.

Figure 17. Evolution of proportions (and 95% confidence intervals) of E. coli, K. pneumoniae and Enterobacter spp. isolates non-susceptible (R+I) to ***ceftiofur*** *in* ***dogs*** *(2017-2022).*

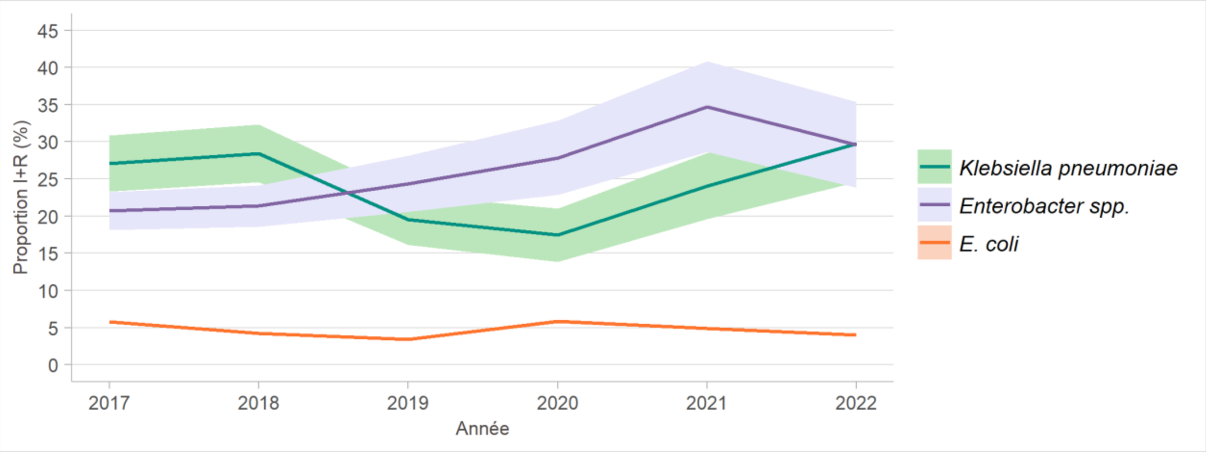


Figure 18. Evolution of proportions (and 95% confidence intervals) of E. coli, K. pneumoniae and Enterobacter spp. isolates non-susceptible (R+I) to ***ceftiofur*** *in* ***horses*** *(2017-2022).*

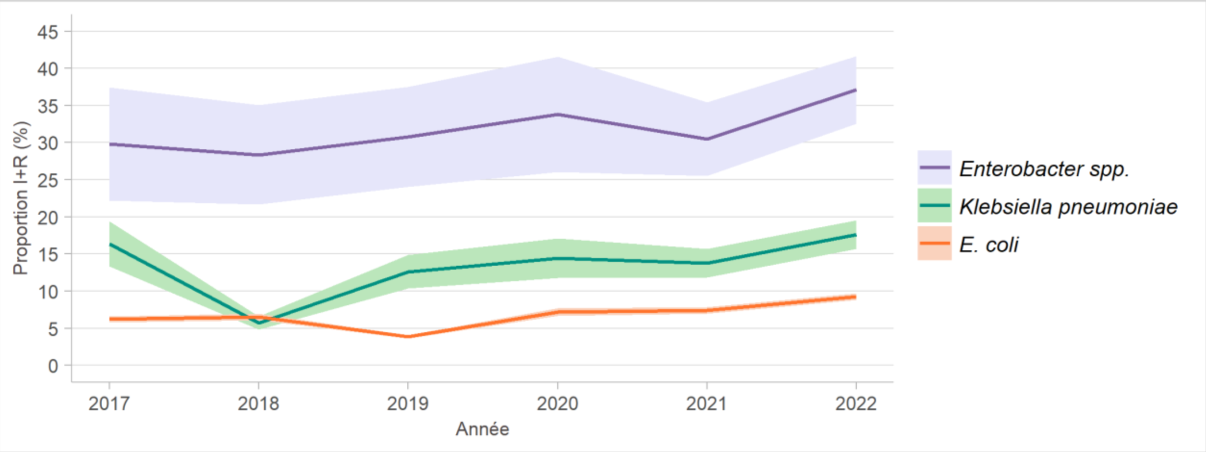


Figure 19. Evolution of proportions (and 95% confidence intervals set) of E. coli, K. pneumoniae and Enterobacter spp. isolates non-susceptible (R+I) to ***enrofloxacin or marbofloxacin*** *in* ***dogs*** *(2017-2022).*

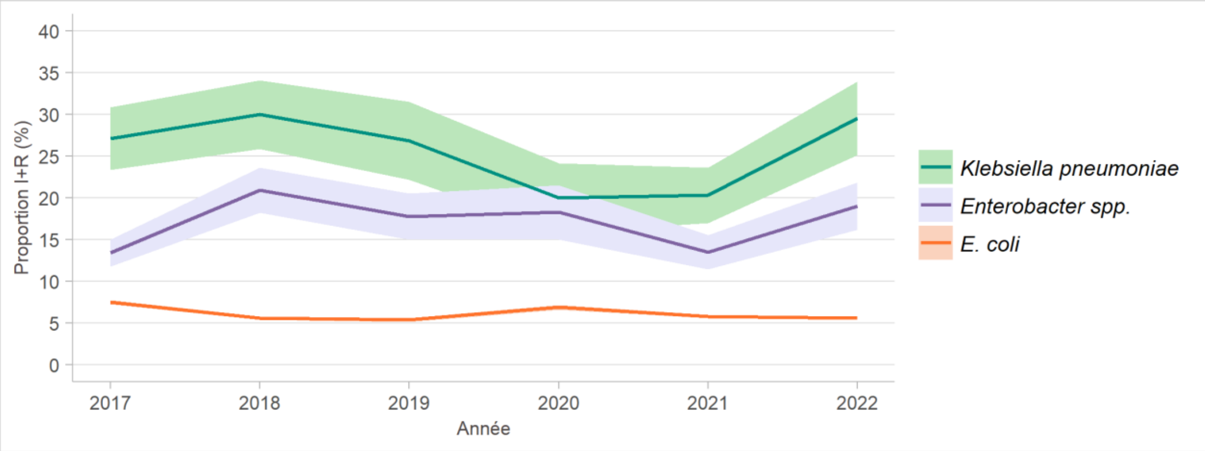
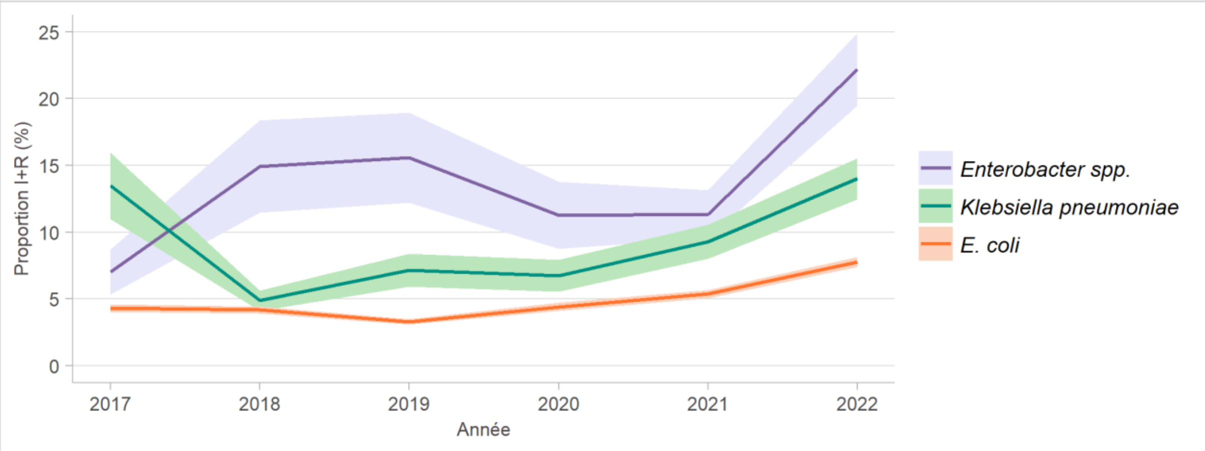


Figure 20. Evolution of proportions (and 95% confidence intervals) of E. coli, K. pneumoniae and Enterobacter spp. isolates non-susceptible (R+I) to ***enrofloxacin or marbofloxacin*** *in* ***horses*** *(2017-2022).*



- ✓ Resistance to 3GC/4GC and fluoroquinolones is systematically higher in *K. pneumoniae* and *Enterobacter* spp. than in *E. coli (Figures 17 to 20).*
- ✓ In 2022, resistance to 3GC/4GC in dogs and horses was 30% and 18% in *K. pneumoniae,* and 30% and 37% in *Enterobacter* spp., respectively *(Figures 17 and 18).*
- ✓ In 2022, resistance to fluoroquinolones in dogs and horses was 30% and 14% in *K. pneumoniae,* and 19% and 22% in *Enterobacter* spp., respectively *(Figures 19 and 20).*
- ✓ The evolution of resistance in *K. pneumoniae* and *Enterobacter spp.* needs to be monitored, both for 3GC/4GC and fluoroquinolones, as it appears to be on an increasing trend.

E. coli - Resistance trends to amoxicillin and amoxicillin-clavulanic acid

Figure 21. Evolution of proportions (%) of E. coli *isolates non-susceptible (R+I) to amoxicillin (2012-2022).*

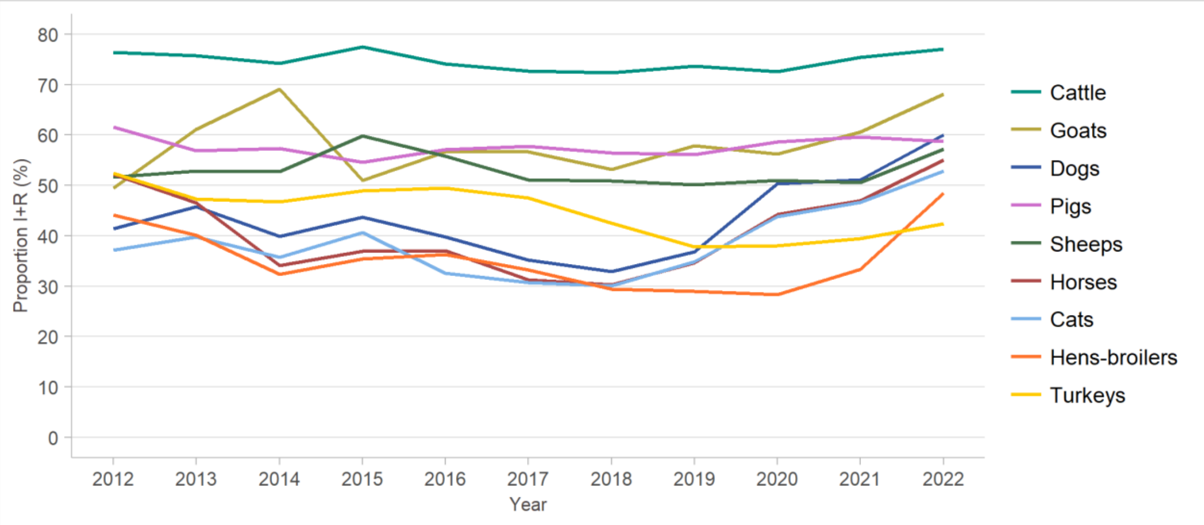
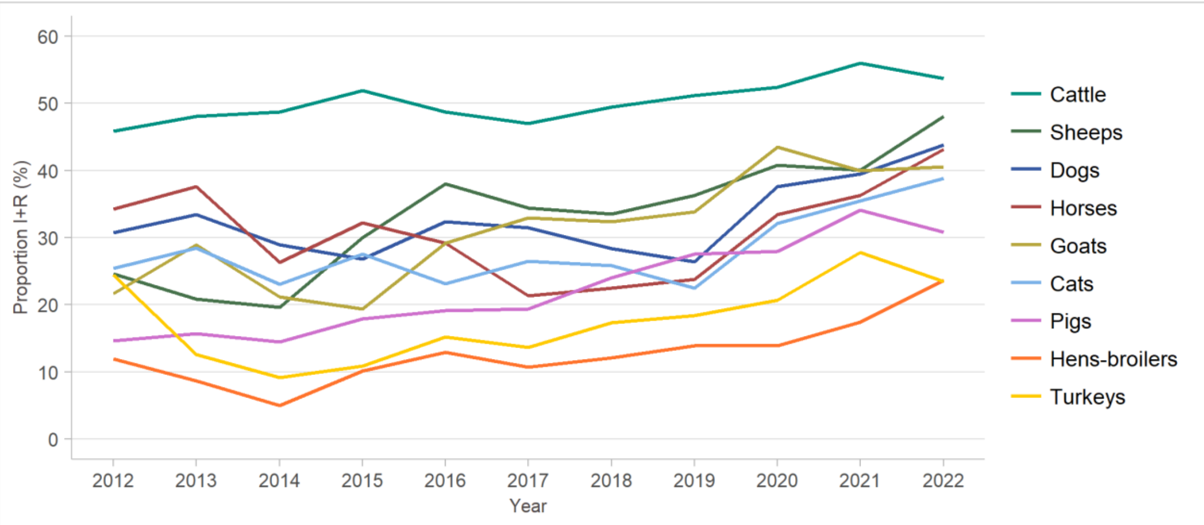


Figure 22. Evolution of proportions (%) of E. coli *isolates non-susceptible (R+I) to amoxicillin-clavulanic acid (2012-2022).*



- ✓ For all animal categories considered, an increase in resistance (R+I) to amoxicillin and amoxicillin-clavulanic acid is observed since 2018, with the exception of turkeys for resistance to amoxicillin (stability) *(Figures 21 and 22).*

- ✓ For these two antimicrobials, the increase is mainly due to isolates categorized as intermediate.

E. coli - Resistance trends to other antibiotics

Method

Resistance trends of *E. coli* to other antibiotics were analyzed for cattle, pigs, poultry (chickens/hens and turkeys separately), dogs, cats and horses.
Six antibiotics representing five antibiotic classes were analyzed.
Data are displayed for the 2012-2022 period.

Figure 23. Evolution of proportions (%) of E. coli *isolates non-susceptible (R+I) to six antimicrobials in* ***cattle*** *(2012-2022).*

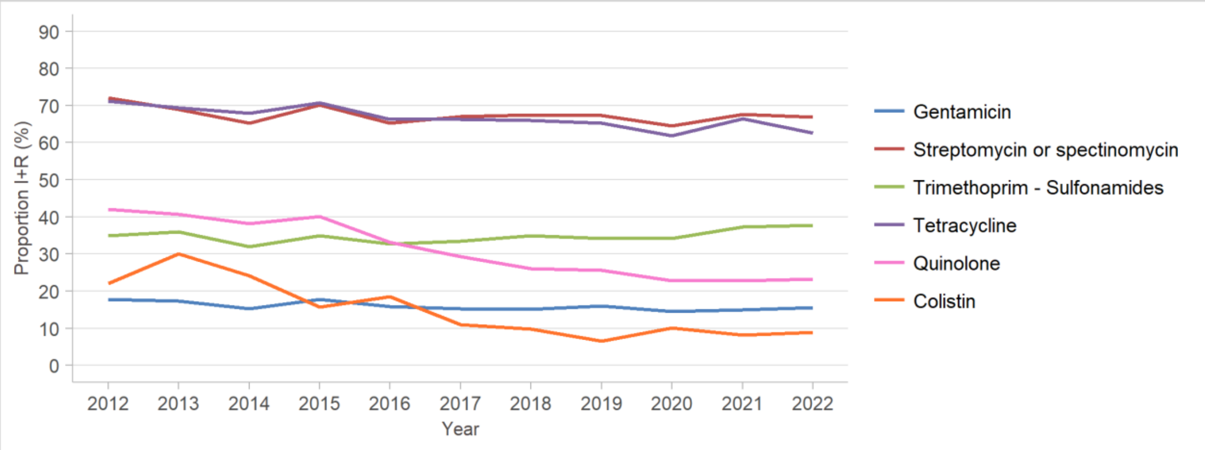


Figure 24. Evolution of proportions (%) of E. coli *isolates non-susceptible (R+I) to six antimicrobials in* ***pigs*** *(2012-2022).*

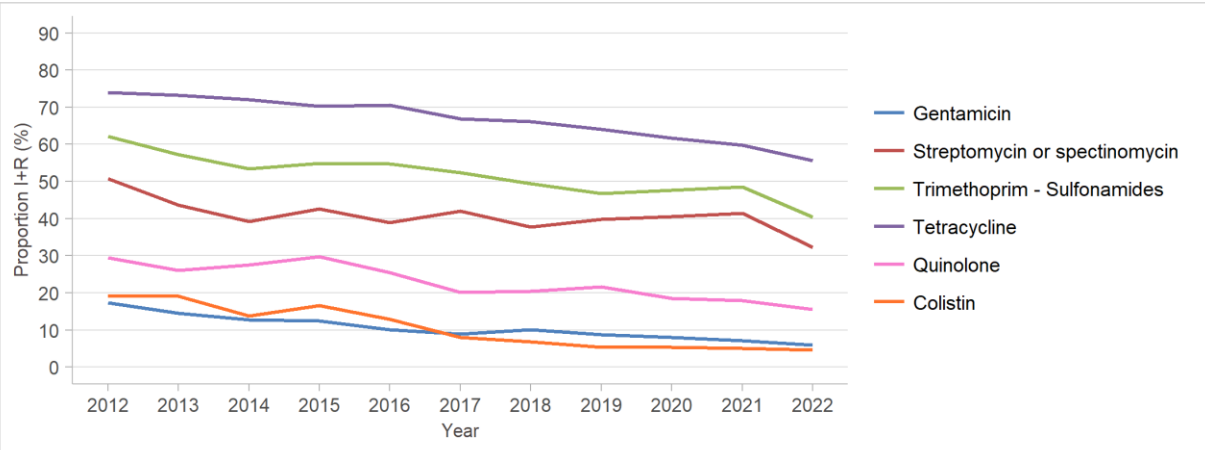


Figure 25. Evolution of proportions (%) of E. coli *isolates non-susceptible (R+I) to six antimicrobials in **hens and broilers** (2012-2022).*

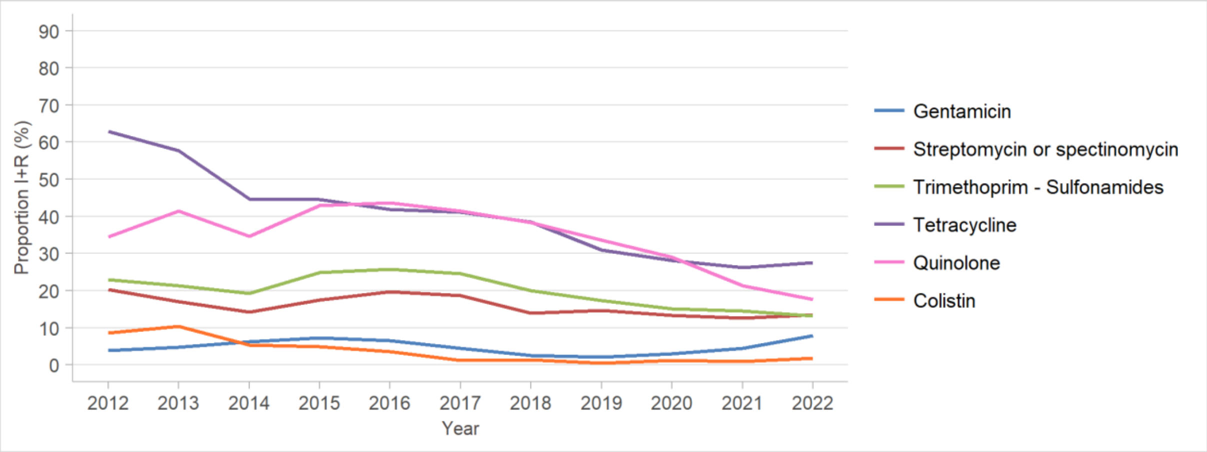


Figure 26. Evolution of proportions (%) of E. coli *isolates non-susceptible (R+I) to six antimicrobials in **turkeys** (2012-2022).*

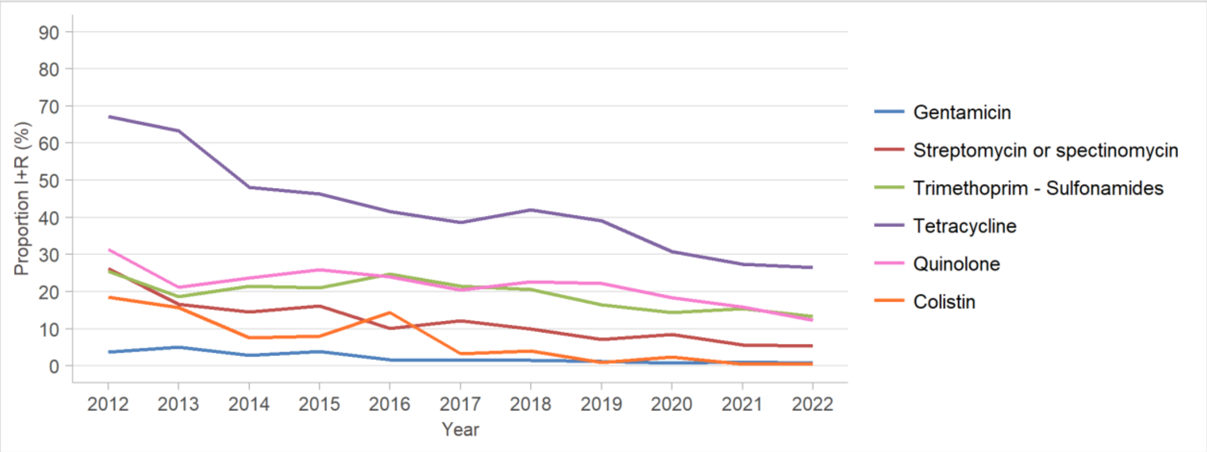


Figure 27. Evolution of proportions (%) of E. coli *isolates non-susceptible (R+I) to six antimicrobials in **dogs** (2012-2022).*

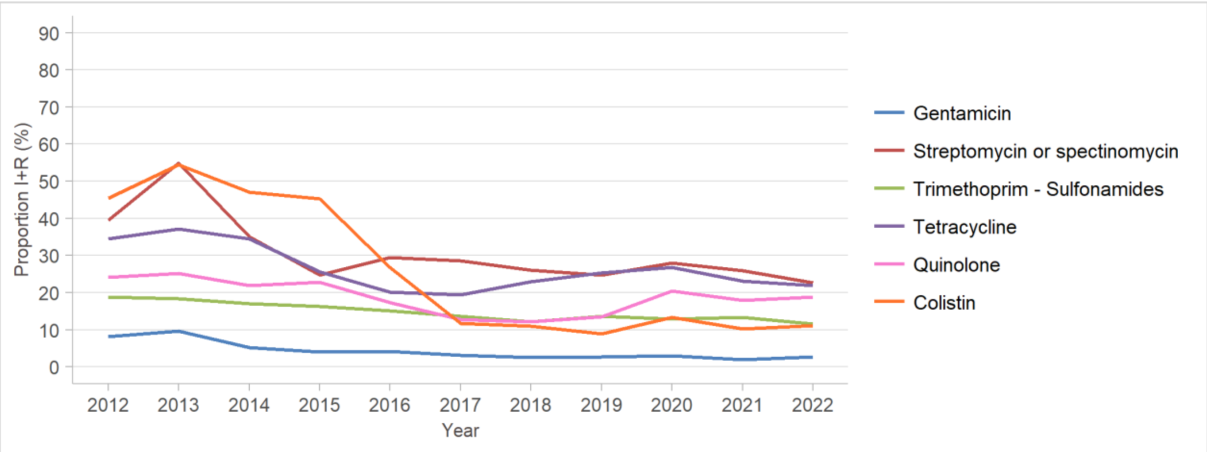


Figure 28. Evolution of proportions (%) of E. coli *isolates non-susceptible (R+I) to six antimicrobials in **cats** (2012-2022).*

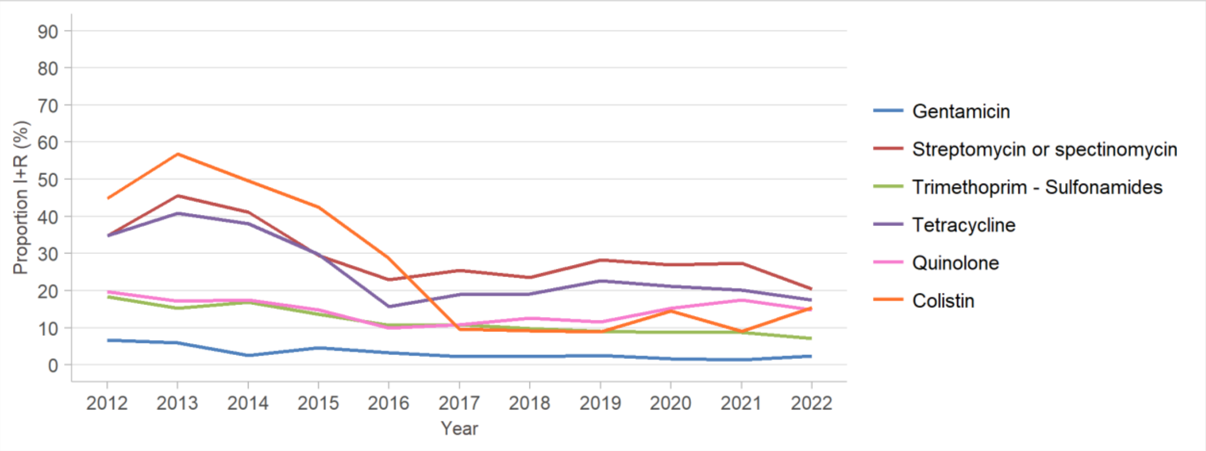
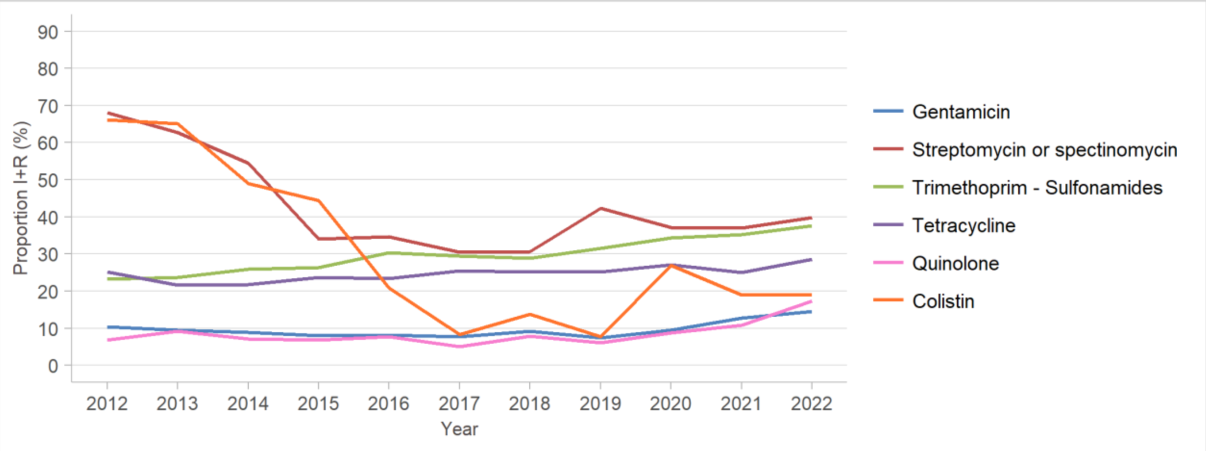


Figure 29. Evolution of proportions (%) of E. coli *isolates non-susceptible (R+I) to six antimicrobials in **horses** (2012-2022).*



- ✓ Overall, resistance trends are downwards for pig and poultry, stable for cattle, dogs and cats and upwards since 2017 for horses *(Figures 23 to 29).*
- ✓ Over the last ten years, resistance to colistin has fallen significantly in all animal species.
- ✓ Over the last ten years, there has also been a significant decline in resistance to tetracyclines and quinolones in farm animals (cattle, pigs and poultry).

E. coli - Multidrug resistance and multidrug susceptibility

The accumulation of resistance mechanisms in bacteria can lead to treatment failures. The evolution of the presence of multidrug resistant (MDR) *E. coli* strains is analyzed annually using Resapath data. In the past, the indicator of multidrug resistance used by the Resapath included resistance to critically-important antimicrobials (3GC/4GC and fluoroquinolones). Considering that resistance to these antibiotic classes has substantially decreased over the past 10 years, the Resapath team has considered it was now less relevant to include them into the definition of multidrug resistance. Since 2021, the multidrug resistance definition has changed as follows.

Method

Multidrug resistance to antimicrobials (MDR) is defined here as acquired resistance (I or R phenotype) to three or more distinct antimicrobial substances among the following ones: amoxicillin, gentamicin, tetracycline, trimethoprim-sulfamethoxazole, nalidixic acid.
Multidrug susceptibility: susceptibility to all five antimicrobials.

Only *E. coli* tested for each of the five antimicrobials were included. Analyses were performed on:

- Evolution of proportions of MDR and multi-susceptible isolates collected between 2012 and 2022.
- Number of resistances (none, 1, 2, 3 4, or 5) for different animal species and age categories.

Figure 30. Evolution between 2012 and 2022 of the proportions (%) of multi-drug resistant E. coli *isolates*

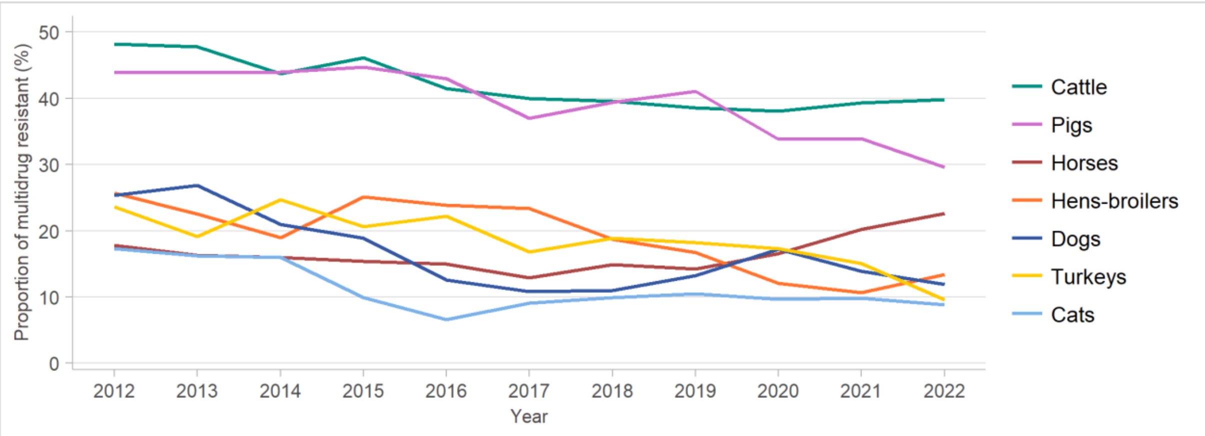
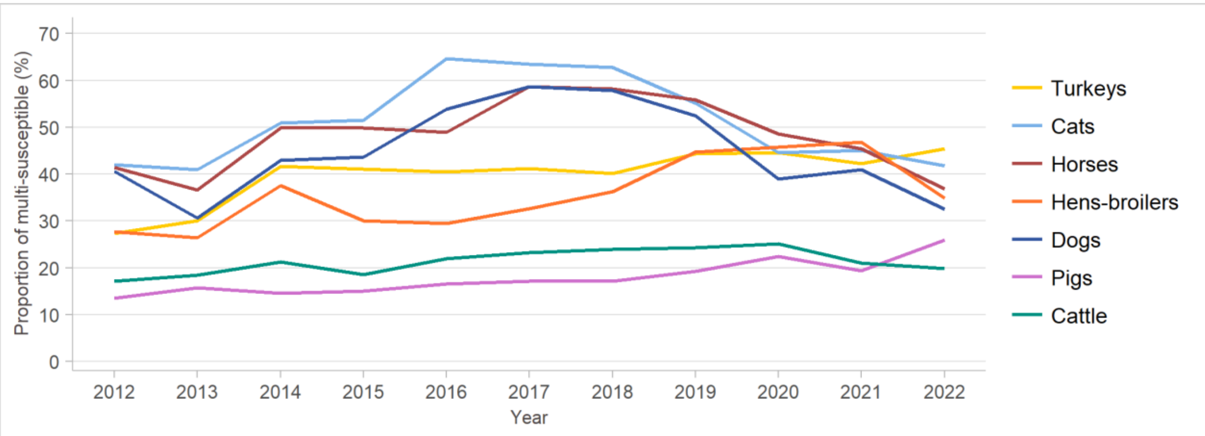


Figure 31. Evolution between 2012 and 2022 of the proportions (%) of *multidrug susceptible* E. coli *isolates*

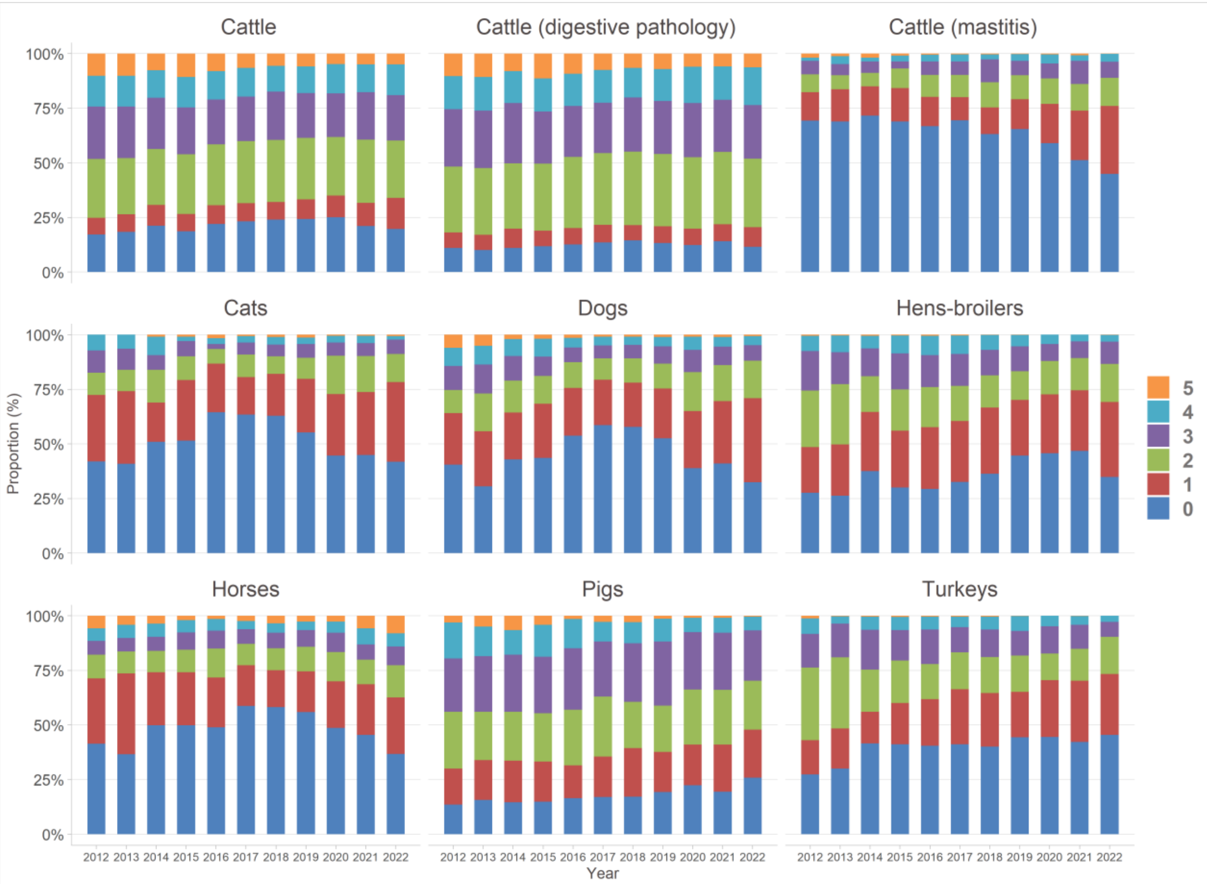


- ✓ The proportions of MDR strains are higher among isolates from bovines (40%), pigs (30%) and horses (22%), compared to those from poultry, dogs and cats (10-12%) *(Figure 30).*

- ✓ The evolution of MDR and multi-susceptibility between 2021 and 2022 are in line with those observed in the recent years, notably:
  (i) a positive evolution over ten years for livestock animals, with reduced proportions of MDR isolates (between -8% and -14%) and increased proportions of multisusceptible isolates especially for pigs (+12%) and turkeys (+18%);
  (ii) a different situation for dogs, cats and horses, with a significant drop in multisusceptible isolates since 2018 (between -21% and -25% depending on the species) and a significant increase in MDR isolates in horses (+10% since 2017), while it has remained stable for five years in dogs and cats *(Figures 30 and 31).*

- ✓ The distribution of isolates according to their phenotype (susceptible to all five antimicrobials, carrying one, two, three, four or five resistances) highlights disparities between animal species *(Figure 32).* Disparities also exist in some cases depending on the pathological context within the same species. For example in cattle in 2022, 48% of the *E. coli* isolates from digestive pathology were MDR versus only 11% for those isolated from mastitis.

Figure 32. Evolution in the proportions of E. coli *isolates resistant to none, 1, 2, 3, 4 or 5 of the antimicrobials tested, for various animal species and pathologies*



Mapping of resistance on the French territory

Geographical data, i.e. the French department or region of origin of the samples sent to the laboratories for antibiotic susceptibility testing, are routinely collected by Resapath. In some cases, these data can be used to map resistance at a French department scale (local administrative unit).

Method

For different combinations of animal species - pathology - bacteria - antibiotic, the proportions of resistance with their 95% confidence intervals are calculated for each department. For each department, the proportion of resistant isolates are compared with the national proportion (test for comparison of proportions considered significant at a level of 5%).

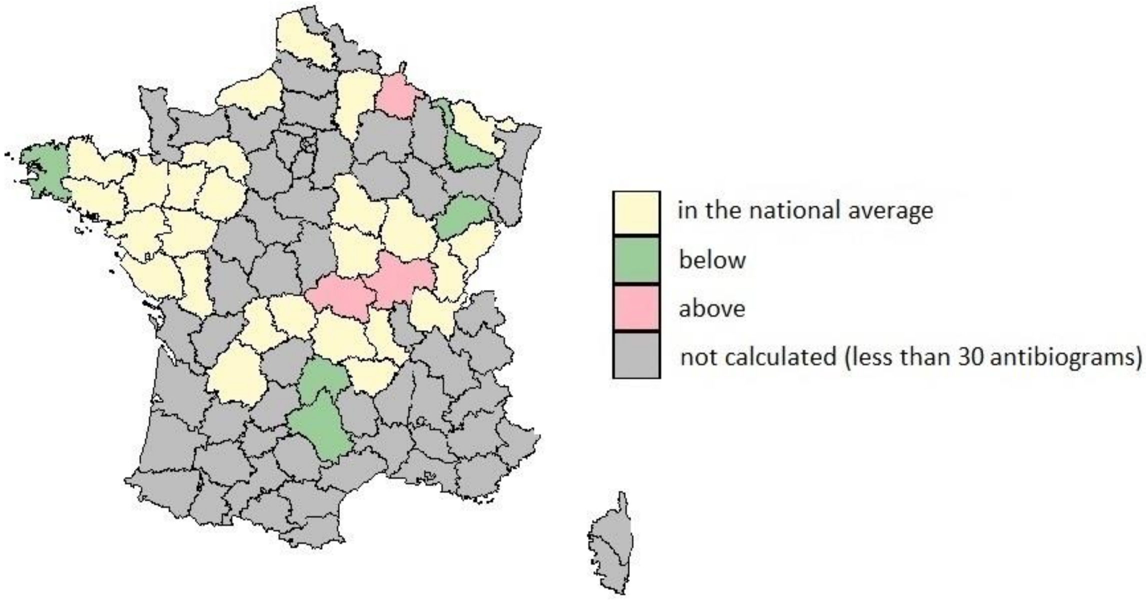
Coloured maps are produced. The departments are classified into four categories:

- Proportion of resistance significantly **higher** than the national proportion (**red**) ;
- Proportion of resistance significantly **lower** than the national proportion (**green**);
- Proportion of resistance **not statistically different** from the national proportion (**yellow**);
- Proportion **not comparable** (<30 antibiograms) (**grey**).

All the maps produced are available on the "RESAPATH online" web application (https://shiny-public.anses.fr/ENresapath2/) in the "Resistance mapping" tab.

Maps have been produced for *E. coli* in young cattle suffering from digestive infections and in cows with mastitis, as well as for *S. pseudintermedius* in dogs. An example is shown below for *E. coli* resistance to gentamicin in young cattle *(Figure 33).*

Figure 33: Map of the proportions of resistant isolates (I+R) in each department compared with the national proportion, for the combination of young cattle - digestive diseases - E. coli - gentamicin (2022).



- ✓ In this example, for three departments (in red), the proportion *E. coli* isolates resistant to gentamicin is statistically higher than the national proportion, and for five others (in green) lower than the national proportion.
- ✓ For the majority of departments (in grey), it was not possible to carry out an analysis due to the lack of a sufficient antibiotic susceptibility tests and/or the availability of geographical data. This is a major limitation to the representation of resistance on a sub-national scale.

Presence of *mcr-1*-carrying *E. coli* in goats

Colistin resistance has become widespread in animals as a result of decades of colistin use in veterinary medicine. In 2015, the first plasmid-mediated resistance gene to colistin, *mcr-1*, was discovered in China[8], then progressively in many countries and continents, under different variants (*mcr-1* to *mcr 11*), in both humans and animals. In the latter, *Escherichia coli* strains carrying the *mcr* genes have been widely identified in cattle, pigs and poultry throughout the world, including France, but very rarely in goats. Our study, in collaboration with a Resapath laboratory (Qualyse), aimed at estimating the prevalence of *E. coli* carrying *mcr*-type genes in 80 breeding farms and five fattening farms in the Poitou-Charentes region.[9]

Only the *mcr-1* gene was identified, in 10% (8/80) of the breeding farms and in four of the five fattening farms. In total, 4.2% (65/1561) of the animals tested in the breeding farms and 60.0% (84/140) of the animals tested in the fattening farms presented an *mcr*-1-positive *E. coli*. The *mcr-1* gene was located either on the chromosome (32.2%) or on the IncX4 (38.9%) and IncHI2 (26.8%) plasmids. As expected, clonal expansion and plasmid transfer were observed in farms where the *mcr-1* gene was located on a plasmid. However, transposition of transposon Tn*6330* carrying the *mcr-1* gene was also observed in the chromosome of various *E. coli* clones within the same farm.

Our results therefore demonstrate the presence of the *mcr-1* colistin resistance gene in the goat industry. They also show that the *mcr-1* gene is mobile, whether it is located on plasmids or on the chromosome (because of its location on a transposon, which ensures its mobility). As a result, only hygiene and biosecurity procedures on farms and the careful use of colistin, like all antibiotics, on fattening farms can break such complex dissemination routes.

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[8] Liu Y-Y, Wang Y, Walsh T.R. et al. (2016) Emergence of plasmid-mediated colistin resistance mechanism MCR-1 in animals and human beings in China: a microbiological and molecular biological study. *The Lancet Infectious Diseases*, Feb; 16(2):161-8. https://doi.org/10.1016/s1473-3099(15)00424-7.

[9] Treilles M, Châtre P, Drapeau A, Madec J-Y, Haenni M. (2023) Spread of the *mcr-1* colistin-resistance gene in *Escherichia coli* through plasmid transmission and chromosomal transposition in French goats. *Frontiers in Microbiology*; 13: 1023403. DOI: 10.3389/fmicb.2022.1023403

Griffon vultures can carry ESBL-producing *E. coli*

Wild birds are potential vectors of antibiotic resistance, even though they are not directly subjected to antibiotic pressure. Indeed, numerous publications have reported the presence of extended-spectrum beta-lactamase (ESBL) and even carbapenemase-producing Enterobacterales in these hosts, probably acquired following contamination of their prey or water sources by humans or other animals.

As obligatory scavengers, griffon vultures (*Gyps fulvus*) are particularly affected by the microbiological quality of the carcasses on which they feed. In France, griffon vultures were reintroduced in the 1990s and their population now numbers over 1,000 individuals. We carried out a preliminary study on cloacal samples from 51 griffon vultures living in the Alps.[10] *E. coli* were isolated from 26 individuals (51%), six of which showed growth on an agar allowing the selection for resistance to third- and fourth-generation cephalosporins (C3G/C4G). Five vultures presented the same *E. coli* ST3274 clone carrying a chromosomally-encoded $bla_{\text{CTX-M-15}}$ gene, in addition to genes conferring resistance to aminoglycosides (*aadA1*) and trimethoprim (*dfrA1*). The sixth vulture presented an *E. coli* ST212 with a derepressed chromosomal *ampC* gene, a mechanism conferring resistance to C3G/C4G.

These results show that living in colonies and close contacts between birds favor the transmission of bacterial clones, including those resistant to antibiotics. This highlights once more the importance of monitoring the emergence of antibiotic resistance in wild animals, since they can contribute to the spread of antibiotic resistance through their release into the environment or their occasional proximity to domestic animals. The levels of antibiotic resistance found in griffon vultures in France remain low compared with other countries, such as Spain, where they are fed carcasses from intensive farms. However, feeding on carcasses from extensive farming, as is the case of the French Alps, does not guarantee the absence of resistance.

[10] Haenni M, Du Fraysseix L, François P, Drapeau A, Bralet T, Madec J-Y, et al. (2023) Occurrence of ESBL- and AmpCproducing *E. coli* in French griffon vultures feeding on extensive livestock carcasses. *Antibiotics*; 12: 1160

EARS-Vet : a pilot study for European surveillance of antimicrobial resistance in veterinary medicine

Since 2018, ANSES has been coordinating an initiative to develop a European network for surveillance of antimicrobial resistance in bacterial pathogens of animals, called EARS-Vet. The work carried out to date has laid the initial foundations for this network. Based on a mapping of existing surveillance systems in the EU/EEA countries,[11] a preliminary network of 11 countries has been established. The partners have agreed on common objectives, a scope and a standardised methodology for EARS-Vet.[12,13]

In 2022, a pilot phase of EARS-Vet was launched, with the aim of evaluating the data available at European level, carrying out an initial joint analysis of these data and formulating recommendations for improving data collection and analysis in the future.[14] Eleven partners from nine EU/EEA countries participated and submitted their antimicrobial susceptibility testing data for the period 2016-2020, representing a total of 140,110 bacterial isolates relating to six animal species and eleven bacterial species of the EARS-Vet scope. RESAPATH was by far the largest contributor and provided 77% of the antimicrobial susceptibility testing data included in the study. The raw data (diameters or minimum inhibitory concentrations) were interpreted using a common methodology and standardised interpretation criteria (epidemiological cut-off values).

The data collected was very diverse and sparse, and for most of the partners covered only parts of the EARS-Vet scope. After cleaning up the data, a joint analysis of resistance trends was carried out for 53 combinations of animal species - bacteria – antibiotic of interest. This work showed high variability in resistance levels, both between countries and within each country (e.g. between animal species), for example for resistance to aminopenicillins in *E. coli* and to fluoroquinolones in *S. pseudintermedius*.

The main difficulties encountered were linked to the lack of harmonisation of antimicrobial susceptibility testing techniques used by veterinary laboratories across Europe, the absence of interpretation criteria for many bacteria - antibiotic pairs of interest, and the lack of data for a large proportion of European countries where surveillance is very limited or non-existent at this stage.

Nevertheless, this pilot study provided a proof of concept of what EARS-Vet can achieve. This work provides an important basis for the future development of the network, in particular for deploying data collection and analysis on a larger scale and on a regular basis. The development of EARS-Vet will continue as part of the EU-JAMRAI2 Joint Action, funded by the European Commission for the period 2024-2027 (EU4Health programme) and coordinated by the French National Institute of Health & Medical Research (INSERM).

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[11] Mader R, Muñoz Madero C, Aasmäe B, et al. (2022) Review and analysis of national monitoring systems for antimicrobial resistance in animal bacterial pathogens in Europe: A basis for the development of the European Antimicrobial Resistance Surveillance Network in Veterinary Medicine (EARS-Vet), *Frontiers in microbiology,* 807.

[12] Mader R, Damborg P, Amat J-P, et al. (2021) Building the European Antimicrobial Resistance Surveillance network in veterinary medicine (EARS-Vet). *Eurosurveillance* 26.4:2001359.

[13] Mader R, Bourély C, Amat J-P, Broens EM, Busani L, Callens B, ... & Madec J-Y. (2022) Defining the scope of the European Antimicrobial Resistance Surveillance network in Veterinary medicine (EARS-Vet): a bottom-up and One Health approach. *Journal of Antimicrobial Chemotherapy*, 77(3), 816-826.

[14] Lagrange J, Amat JP, Ballesteros C, Damborg P, Grönthal T, Haenni M, ... & Collineau L. (2023). Pilot testing the EARS-Vet surveillance network for antibiotic resistance in bacterial pathogens from animals in the EU/EEA. *Frontiers in Microbiology,* 14, 1188423.

Surv1Health : mapping of the French system for surveillance of antimicrobial resistance

The international organisations and government bodies are calling for the implementation of One Health surveillance systems to provide integrated management of infectious diseases at the interface between human health, animal health and the environment. These recommendations apply in particular to surveillance of antimicrobial resistance (AMR). In France, multiple programmes for surveillance of AMR, antimicrobial use and antimicrobial residues have been in place for several years. However, the number and diversity of these programmes make it difficult to obtain a comprehensive overview of the surveillance system as a whole, and of the level of collaboration between programmes.

Funded by the Ecoantibio2 plan for the period 2020-2023, and in collaboration between ANSES, the French Ministry of Agriculture and Food Sovereignty, Santé Publique France and VetAgro-Sup, the Surv1Health project aimed to assess collaboration between programmes for surveillance of AMR, antimicrobial use and antimicrobial residues in France and identify areas for improvement towards integrated surveillance.

On the basis of the literature and 51 interviews conducted with programme coordinators (n=36) and surveillance experts (n=15), the study showed that 48 surveillance programmes were contributing to the French surveillance system in 2021 (Figure 34), including 34 in the human sector, 14 in the animal/food sector (including RESAPATH) and one in the environment.[15] Only two programmes were cross-sectoral, collecting data from both humans and animals/food. Nevertheless, four sub-systems (made up of three or more programmes) facilitated collaboration within and between sectors. Indicators for monitoring antimicrobial use varied widely between programmes. For resistance data, the standards used to interpret antimicrobial susceptibility testing differed between the human and animal sectors.

Collaboration between surveillance programmes was operational in terms of communicating results, for example via the production of a One Health brochure disseminated at the occasion of the annual world antimicrobial awareness week.[16] However, the sharing and joint analysis of data from the various programmes appeared insufficient. The thematic analysis showed that collaboration was mainly fostered by good relationships between coordinators, their interest in transdisciplinary approaches and the perceived impact of collaboration.[17] Conversely, limited resources and the lack of visibility of the surveillance system tended to hinder collaboration.

Overall, this study showed that France currently has a rich but complex and fragmented surveillance system, with limited integration between sectors and hazards (AMR/antimicrobial use/ antimicrobial residues). The main gaps concerned coverage of the environmental sector (sparse and not permanent at this stage), monitoring of antimicrobial use in companion animals, and coverage of overseas territories in animal health. On the other hand, certain redundancies were observed in the human sector AMR surveillance at hospital.

Twelve recommendations were formulated and shared with the relevant ministries to improve the One Health-ness of the French surveillance system and inform future strategies to combat antimicrobial resistance.

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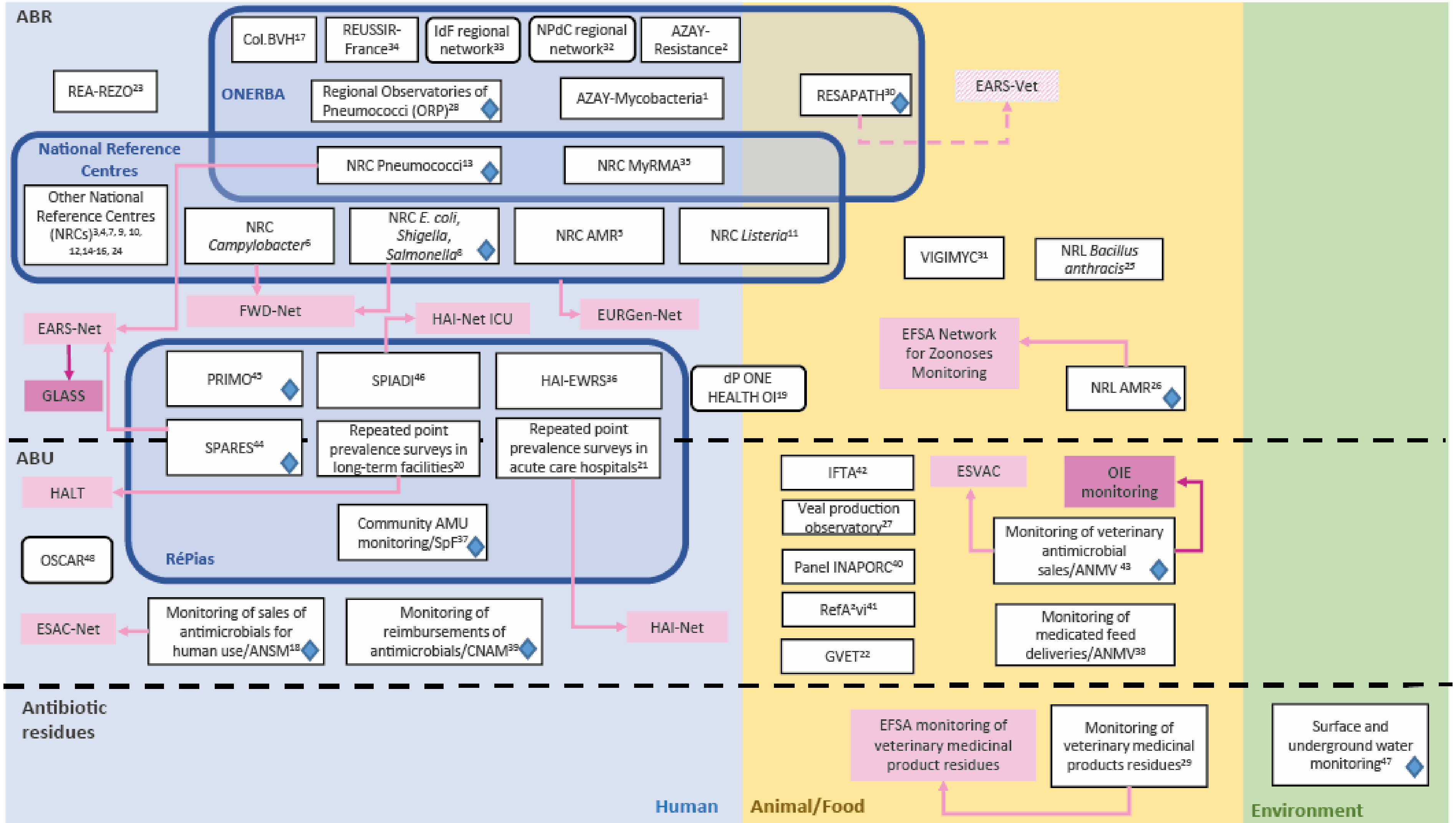
15 Collineau L, Bourély C, Rousset L, Berger-Carbonne A, Ploy MC, Pulcini C & Colomb-Cotinat M. (2023). Towards One Health surveillance of antibiotic resistance: characterisation and mapping of existing programmes in humans, animals, food and the environment in France, 2021. *Eurosurveillance,* 28(22), 2200804.

16 Santé publique France (2022) Prévention de la résistance aux antibiotiques - une démarche une seule santé. Santé publique France, pp.1-25, https://www.santepubliquefrance.fr/content/download/538878/3931914?version=1

17 Bourély C, Rousset L, Colomb-Cotinat M, & Collineau L (2023). How to move towards One Health surveillance? A qualitative study exploring the factors influencing collaborations between antimicrobial resistance surveillance programmes in France. *Frontiers in Public Health*, 11.

Figure 34 : Mapping of the existing surveillance programmes for antibiotic resistance (ABR), antibiotic use (ABU) and antibiotic residues in humans, animals/food and the environment in France in 2021 (n = 48 programmes)



Source : Collineau L, Bourély C, Rousset L, Berger-Carbonne A, Ploy MC, Pulcini C & Colomb-Cotinat M. (2023). Towards One Health surveillance of antibiotic resistance: characterisation and mapping of existing programmes in humans, animals, food and the environment in France (2021). *Eurosurveillance*, 28(22), 2200804.

Appendices

Appendix 1. Laboratories contributing to Resapath (2022)

Laboratoire Départemental d'Analyses
Chemin de la Miche Cénord
01012 BOURG-EN-BRESSE CEDEX

Laboratoire Départemental d'Analyses
et de Recherche
180 Rue Pierre Gilles de Gennes
ZA du Griffon
BARENTON BUGNY
02007 LAON CEDEX

Eurofins Laboratoire Coeur de France
Zone Industrielle de l'Etoile
Boulevard de Nomazy
BP 1707
03017 MOULINS CEDEX

SELARL VETALLIER
96 Grand Rue
03420 MARCILLAT-EN-COMBRAILLE

Laboratoire Départemental Vétérinaire
et Hygiène Alimentaire
5 rue des Silos
BP 63
05002 GAP CEDEX

Laboratoire Vétérinaire Départemental
105 route des Chappes
06410 BIOT

Laboratoire Départemental d'Analyses
Rue du chateau
BP 2
08430 HAGNICOURT

Laboratoire d'Analyses Vétérinaires et
Alimentaires du département
Chemin des Champs de la Loge
CS 70216
10006 TROYES CEDEX

Aveyron Labo
Parc d'activités de Bel Air
195 Rue des Artisans
12031 RODEZ CEDEX 9

Laboratoire Départemental d'Analyses
29 rue Jolliot Curie
Technopole de Château-Gombert
CS 60006
13455 MARSEILLE CEDEX 13

ANSES laboratoire de pathologie
équine de Dozulé, RD 675
14430 GOUSTRANVILLE

LABEO Frank DUNCOMBE
1 route de Rosel
14053 SAINT-CONTEST CEDEX 4

VETODIAG
6 Route du Robillard
14170 SAINT-PIERRE-EN-AUGE

Laboratoire Terana Cantal
100 rue de l'Egalité
15013 AURILLAC CEDEX

Laboratoire Départemental d'Analyses
de la Charente
496 route de Bordeaux
16000 ANGOULEME

Laboratoire Terana Cher
216 rue Louis Mallet
18000 BOURGES

Laboratoire Départemental de la Côte-d'Or
2 ter rue Hoche, CS 71778
21017 DIJON CEDEX

LABOCEA PLOUFRAGAN
5-7 rue du Sabot
22440 PLOUFRAGAN

LABOFARM
4 rue Théodore Botrel
BP 351
22600 LOUDEAC

LABOFARM ARMOR
Kergré
22970 PLOUMAGOAR

VET&SPHERE Quintin
12 Rue de la Corderie
22800 QUINTIN

Laboratoire Départemental d'Analyses
42-44, route de Guéret
23380 AJAIN

Laboratoire Départemental d'Analyse
et de Recherche
161 Avenue Winston Churchill
24660 COULOUNIEIX-CHAMIERS

Laboratoire Vétérinaire Départemental
13 rue Gay-Lussac
BP 1981
25020 BESANCON CEDEX

AGRILAB 4A
5 Rue Gautier Lucet
ZA Les Gouvernaux
26120 CHABEUIL

LBAA
ZI allée du Lyonnais
26300 BOURG-DE-PEAGE

KER-VET
2B Avenue du Maréchal Leclerc
29610 PLOUIGNEAU

LABOCEA QUIMPER
22 Avenue de la plage des Gueux
ZA de Creach Gwen
CS 13031
29334 QUIMPER CEDEX

Laboratoire Départemental d'Analyses
970 route de St Gilles
ZAC mas des abeilles
30000 NIMES

LD 31 EVA
76, chemin Boudou
31140 LAUNAGUET

SOCSA Analyse
11 Bis Rue Ariane
31240 L'UNION

Public labos site du Gers
824 Chemin de Naréoux
32020 AUCH CEDEX 9

Laboratoire Départemental Vétérinaire
306 rue de Croix Las Cazes
CS 69013
34967 MONTPELLIER CEDEX 2

BIOCHENE VERT
Z.I. Bellevue II
Rue Blaise Pascal
35220 CHATEAUBOURG

BIOVILAINE
Z.A. des Chapelets
87 rue de la Chataigneraie
35600 REDON

Laboratoire Biovilaine Janzé
57 Rue Paul Painlevé
35150 JANZE

LABORATOIRE DE BROCELIANDE
Rue Pasteur
ZA du Maupas
35290 SAINT-MEEN-LE-GRAND

LABOCEA - site de Fougères
BioAgroPolis
10 Rue Claude Bourgelat
JAVENE
CS 30616
35306 FOUGERES CEDEX

Laboratoire des sources
Boulevard de la Cote du Nord
35133 LECOUSSE

MC Vet Conseil - Velvet
47 Boulevard Leclerc
35460 SAINT-BRICE-EN-COGLES

INOVALYS TOURS
3 Rue de l'aviation
37210 PARCAY-MESLAY

Laboratoire Vétérinaire Départemental
20 avenue St Roch
38000 GRENOBLE

Laboratoire Départemental d'Analyses
59 rue du Vieil Hôpital
BP 40135
39802 POLIGNY CEDEX 2

BIOSUD ANALYSES - SOCSA
283 Avenue du Béarn
BP5
40330 AMOU

Laboratoire des Pyrénées et des Landes
1 rue Marcel David
BP 219
40004 MONT-DE-MARSAN CEDEX

MC Vet Conseil - Naveil
9 Rue du Clos-Haut de la Bouchardière
41100 NAVEIL

Laboratoire TERANA LOIRE
Zone Industrielle de Vaure
7 Avenue Louis Lépine
CS80207
42605 MONTBRISON CEDEX

Bio-Chêne Vert Varades
ZAC du Point du Jour
44370 VARADES

INOVALYS NANTES
Route de Gachet
BP 52703
44327 NANTES CEDEX 03

LABOVET CONSEIL ANCENIS
125 Rue Georges Guynemer
ZAC de l'Aeropole
44150 ANCENIS SAINT GEREON

MC Vet Conseil - Quiers
8 Zone d'activités
45270 QUIERS-SUR-BEZONDE

SOCSA ELEVAGE, SELARL
de vétérinaires du Val Dadou
ZI Piquemil
47150 MONFLANQUIN

Laboratoire Départemental d'Analyses
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48005 MENDE CEDEX

SARL ALVETYS
1 Rue Gillier
49500 SEGRE-EN-ANJOU-BLEU

INOVALYS ANGERS
18 bd Lavoisier
Square Emile Roux
BP 20943
49009 ANGERS CEDEX 01

LABOVET BEAUPREAU
130, Rue des forges
ZI Evre et Loire
49600 BEAUPREAU-EN-MAUGES

YZIVET
ZA de la Charte Bouchère
49360 YZERNAY

LABEO Manche
1352 Avenue de Paris
CS 33608
50008 SAINT-LO CEDEX

Laboratoire Départemental d'Analyse
Rue du Lycée Agricole
CHOIGNES
CS 32029
52901 CHAUMONT CEDEX 9

Laboratoire Départemental d'Analyses
224 rue du Bas des Bois
BP 1427
53014 LAVAL CEDEX

MC Vet Conseil - Lab-elvet
1 Rue Charles Nicolle
53810 CHANGE

Laboratoire Vétérinaire et Alimentaire Départemental
Domaine de Pixérécourt
BP 60029
54220 MALZEVILLE

LABOFARM MOREAC
ZA Du Bronut
56500 MOREAC

INOVALYS VANNES
5 rue Denis Papin
BP 20080
56892 SAINT-AVE CEDEX

Laboratoire RESALAB BRETAGNE
site Anibio
ZI du Douarin
56150 GUENIN

SELARL VET&SPHERE Malestroit
Zone industrielle de Tirpen
56140 MALESTROIT

TERANA NIEVRE
Rue de la Fosse aux loups
58000 NEVERS

Laboratoire Départemental Public
Domaine du CERTIA
369 rue Jules Guesde
BP 20039
59651 VILLENEUVE-D'ASCQ CEDEX

LABEO ORNE
19 rue Candie
CS 60007
61001 ALENCON CEDEX

AABIOVET
29 Quai du haut pont
62500 SAINT-OMER

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Parc de Haute Technologie des Bonnettes
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62022 ARRAS CEDEX

TERANA Puy de Dôme
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63370 LEMPDES

Bio-Chêne Vert Arzacq Arraziguet
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64410 ARZACQ ARRAZIGUET

Laboratoires des Pyrénées et des Landes
88 Rue des Écoles
Site de Lagor
64150 LAGOR

FILIAVET SELESTAT
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67200 STRASBOURG

Laboratoire Alsacien d'Analyses (L2A)
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ORBIO LABORATOIRE
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69500 BRON

Laboratoire Départemental Vétérinaire et d'Hydrologie
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70000 VESOUL

Laboratoire AGRIVALYS 71
Espace DUHESME
18 Rue de Flacé
71000 MACON

Laboratoire Val de Saône
159 Rue de Bourgogne
71680 CRECHES-SUR-SAONE

Bio-Chêne Vert Saint-Mars
72470 SAINT MARS LA BRIERE

INOVALYS LE MANS
128 rue de la Beaugé
72018 LE-MANS CEDEX

MC Vet Conseil - Sablé
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72300 SABLE-SUR-SARTHE

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73024 CHAMBERY CEDEX

Lidal - laboratoire vétérinaire départemental
22 rue du Pré Fornet
SEYNOD
CS 70042
74600 ANNECY

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76175 ROUEN CEDEX

Bio-Chêne Vert Secondigny
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BP 30019
79130 SECONDIGNY

FILIAVET BRESSUIRE
7 rue des artisans
Zone Alphaparc sud
79300 BRESSUIRE

QUALYSE
ZAE Montplaisir
79220 CHAMPDENIERS

QUALYSE
ZAE Montplaisir
79220 CHAMPDENIERS

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80044 AMIENS CEDEX 1

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375 rue Jean Aicard
83300 DRAGUIGNAN

VET'ANALYS
1128 Route de Toulon
Pôle d'activité Hyèrois
83400 HYERES

Laboratoire Départemental d'Analyses
285 rue Raoul Follereau
BP 852
84082 AVIGNON CEDEX 2

ANI-MEDIC
52 Rue du Bourg Bâtard
85120 LA-TARDIERE

Bio-Chêne Vert Les Essarts
2, rue du Cerne
ZI La Mongie
85140 LES ESSARTS

LABOVET CONSEIL (CHALLAND)
15 Rue Christophe COLOMB
Parc des judices
85300 CHALLANS

LABOVET CONSEIL site des Essarts
28 rue des Sables
85140 ESSARTS-EN-BOCAGE

LABOVET
ZAC de la Buzenière
BP 539
85500 LES-HERBIERS

LCE, SELARL Mathon et Bonal
8 Rue Denis Papin
ZA de Mirville - Bellevue
BOUFFERE
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Laboratoire de l'Environnement et de l'Alimentation de la Vendée
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85021 LA-ROCHE-SUR-YON CEDEX

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87005 LIMOGES

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88050 EPINAL CEDEX 09

AUXAVIA
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89470 MONETEAU

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Ecole Nationale Vétérinaire d'Alfort
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94704 MAISONS-ALFORT CEDEX

VEBIO
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94117 ARCUEIL CEDEX

Appendix 2. Resapath performance indicators

Performance indicators (PIs) are quantitative tools for monitoring the proper functioning and operations of an epidemiological surveillance network. These performance indicators are essential to identify the weak points of an activity and adopt the optimal corrective measures. For Resapath, sixteen indicators are being monitored. The results are presented for the period 2018-2022 and discussed for the year 2022 *(Table 1).*

Table 1 - Resapath performance indicators for the years 2018 to 2022

In green: result equal to or greater than the expected value | In pink: result lower than the expected value

	Indicator		Expected value	2018	2019	2020	2021	2022	Comments
NETWORK OPERATIONS	IP1a	Number of collected antibiograms	*Steady or increase*	55,401	53,469	51,736	62,070	70,603	The major developments in the IT system implemented in 2021 made it possible to continue expanding the network with the addition of seven new laboratories in 2022 and +13% of collected antibiograms compared to 2021. A laboratory left the network because it was unable to comply with the terms of the membership charter.
	IP1b	Number of contributing laboratories (laboratory sites)	*Steady or increase*	74	75	77	101	108	
	IP1c	Proportion of laboratories having transmitted their antibiograms data	*90%*	100%	100%	100%	99%	100%	
	IP1d	Proportion of laboratories transmitting their data at a rate consistent with the membership charter (at least quarterly)	*80%*		*Not available*		71%	96%	Laboratories were made aware throughout the year of the importance of regularly sending their data for the proper functioning of the network. The efforts made are visible considering that 96% of laboratories sent their data to ANSES at least quarterly, in 2022.
	IP1e	Proportion of antibiograms received at ANSES and included in the database within 4 months upon analysis of the sample	*60%*	79%	79%	60%	74%	97%	Despite the very large increase in the number of data to be processed by ANSES in the recent years, the pace of their integration into the Resapath database reached a very satisfactory level in 2022. This performance underlines the effectiveness of the new IT system put in place for data processing at ANSES and the strong engagement of the network's technical secretariat in this task.

		Indicator	Expected value	2018	2019	2020	2021	2022	Comments
	IP1f	Completeness: proportion of antibiograms with fully documented and usable data1	*70%*	**71%**	**70%**	**67%**	**62%**	**54%**	The completeness of the data is in sharp decline for the 3rd consecutive year. This situation is partly linked to the integration into the network of new laboratories which have not yet managed to fully comply with the network's expectations, but also to a decline in data completeness for laboratories which have been Resapath members for a long time. Initiatives have been taken, e.g. group and individual training, to raise awareness among these laboratories. The diffusion to each laboratory of an annual and individual report on the quality of the data provided is being discussed and could help to further improve the situation.
SRAINS	IP2a	Proportion of strains requested by ANSES and actually received (excluding project mode)	*50%*	**76%**	**68%**	**63%)**	**64%**	**70%**	Despite a significant increase in the quantity of strains requested (+76% in 2021, +30% in 2022), the transmission rate of strains by member laboratories remains very good. It is the case, both for the number of strains transmitted and the delay of their transmission.
SRAINS	IP2b	Proportion of strains received within 31 days upon request by ANSES	*80%*	**81%**	**80%**	**83%**	**80%**	**83%**	
COORDINATION	IP3a	Publication rate of annual reports (number of reports expected per year =1)	*100%*	**100%**	**100%**	**100%**	**100%**	**100%**	The 2021 annual results were published in November 2022 in both French and English language. The data are accessible via the electronic annual report presenting the main monitoring results with commentary and via the Resapath online application which provides detailed figures.
COORDINATION	IP3b	Website update frequency (maximum 3-month period expected between two updates of the website)	*100%*	*No regular update*					The Resapath website is made available to members of the network and more generally to Internet users. It is regularly used to post documents online for member laboratories but its content is not sufficiently updated. The website will be more completely updated in 2023.
COORDINATION	IP3c	Completion rate of the steering committee meeting (number of meetings expected per year=1)	*100%*	**100%**	**100%**	**0%**	**100%**	**100%**	In 2022, new members joined the steering committee in order to broaden its scope of expertise, in particular concerning the equine sector, companion animals but also human medicine.

	Indicator		Expected value	2018	2019	2020	2021	2022	Comments
SCIENTIFIC & TECHNICALL SUPPORT	IP4a	Taux de réalisation des journées de restitution, de formation et d'échanges Résapath	*100%*	**100%**	**100%**	**100%**	**100%**	**0%**	The annual day of training and exchange with laboratories initially scheduled in person in December 2022 could not be held due to strikes impacting the travel of participants. The day was by default postponed to March 2023 and was held by videoconference.
	IP4b	Completion rate of Resapath laboratories meeting (feedback, training and exchanges) (number of meetings expected per year=1)	*65%*	**54%**	**45%**	*Not available*			
	IP4c	Rate of responses given within 15 days upon reception of the question from the member laboratories	*60%*	**70%**	**72%**	**77%**	**89%**	**79%**	In 2022, for 79% of the requests asked by member laboratories, a response was provided by the Resapath team within 15 days. This result demonstrates the efforts made by the Resapath team to continue its engagement into these exchanges.
	IP4d	Laboratories participation rate in the ring trial[18]	*100%*	**100%**	**100%**	**99%**	**99%**	**100%**	The results obtained by the laboratories at the annual ring trial organized by Resapath are very satisfactory. All laboratories participated and all obtained a score above 31 out of 36.
	IP4e	Rate of laboratories having a score greater or equal to 31/36 to ring trial part[19]	*95%*	**97%**	**99%**	**99%**	**100%**	**100%**	

[18] The data used to estimate the completeness of the data are the sample department of origin, the age of the animal, the type of sample and/or the pathology.

[19] Some laboratories with several laboratory sites carry out the annual ring trial as a group and return a single result. Each site is counted as a participant and assigned a unique score. Only laboratories that were Resapath members at the time of the ring trial are counted in the denominator.

Appendix 3. Publications linked to Resapath activities (2022)

International peer-reviewed publications

Dierikx C, Börjesson S, Perrin-Guyomard A, Haenni M, Norström M et al. (2022) A European multicenter evaluation study to investigate the performance on commercially available selective agar plates for the detection of carbapenemase producing Enterobacteriaceae. *Journal of Microbiological Methods*. 193 106418. DOI: 10.1016/j.mimet.2022.106418

Garcia-Fierro R, Drapeau A, Dazas M, Saras E, Rodrigues C, Brisse S, Madec J-Y, Haenni M (2022) Comparative phylogenomics of ESBL-, AmpC- and carbapenemase-producing *Klebsiella pneumoniae* originating from companion animals and humans. *Journal of Antimicrobial Chemotherapy*. 77(5):1263-1271. DOI: 10.1093/jac/dkac041

Haenni M, Boulouis HJ, Lagrée AC, Drapeau A, Va F et al. (2022) Enterobacterales high-risk clones and plasmids spreading bla ESBL/AmpC and bla OXA-48 genes within and between hospitalized dogs and their environment. *Journal of Antimicrobial Chemotherapy.* 77(10):2754-2762. DOI: 10.1093/jac/dkac268

Haenni M, Dagot C, Chesneau O, Bibbal D, Labanowski J et al. (2022) Environmental contamination in a high-income country (France) by antibiotics, antibiotic-resistant bacteria, and antibiotic resistance genes: Status and possible causes. *Environment International.* 159:107047. DOI: 10.1016/j.envint.2021.107047

Haenni M, Métayer V, Lupo A, Drapeau A, Madec J-Y (2022) Spread of the bla(OXA-48)/IncL Plasmid within and between Dogs in City Parks, France. *Microbiology Spectrum*. 10(3):e0040322. DOI: 10.1128/spectrum.00403-22

Mader R, Bourély C, Amat J-P, Broens EM, Busani L et al. (2022) Defining the scope of the European Antimicrobial Resistance Surveillance network in Veterinary medicine (EARS-Vet): a bottom-up and One Health approach. *Journal of Antimicrobial Chemotherapy.* 77(3):816–826. DOI: 10.1093/jac/dkab462

Mader R, Muñoz Madero C, Aasmäe B, Bourély C, Broens E et al. (2022) Review and Analysis of National Monitoring Systems for Antimicrobial Resistance in Animal Bacterial Pathogens in Europe: A Basis for the Development of the European Antimicrobial Resistance Surveillance Network in Veterinary Medicine (EARS-Vet). *Frontiers in Microbiology.* 13:838490, 838491-838412. DOI: 10.3389/fmicb.2022.838490

Nunez-Garcia J, Abuoun M, Storey N, Brouwer MS, Delgado-Blas JF et al. (2022) Harmonisation of in-silico next-generation sequencing based methods for diagnostics and surveillance. *Scientific Reports*. 12:14372. DOI: 10.1038/s41598-022-16760-9

Reid CJ, Cummins ML, Börjesson S, Brouwer MSM, Hasman H et al. (2022) A role for ColV plasmids in the evolution of pathogenic *Escherichia coli* ST58. *Nature Communications.* 13(1):683. DOI: 10.1038/s41467-022-28342-4

Tegegne HA, Madec J-Y, Haenni M (2022) Is methicillin-susceptible *Staphylococcus aureus* (MSSA) CC398 a true animal-independent pathogen? *Journal of Global Antimicrobial Resistance*. 29:120-123. https://linkinghub.elsevier.com/retrieve/pii/S2213716522000510

Valat C, Haenni M, Arnaout Y, Drapeau A, Hirchaud E et al. (2022) F74 plasmids are major vectors of virulence genes in bovine NTEC2. *Letters in Applied Microbiology.* 75(2):355-362. DOI: 10.1111/lam.13733

National publications

Madec J-Y. Soigner par antibiothérapie. Guide pour un bon usage des antibiotiques chez les animaux de compagnie. Deuxième édition - September, Afvac. 2022:9-11/388pp.

Madec J-Y. Notions générales sur l'antibiorésistance. Dans: Guide pour un bon usage des antibiotiques chez les animaux de compagnie. Deuxième édition - September, Afvac. 2022:12-14/388pp.

Madec J-Y. Le vétérinaire face à l'antibiorésistance. Dans: Guide pour un bon usage des antibiotiques chez les animaux de compagnie. Deuxième édition - September, Afvac. 2022:15-17/388pp.

Madec J-Y. L'antibiothérapie ne fait pas tout. Guide pour un bon usage des antibiotiques chez les animaux de compagnie. Dans: Guide pour un bon usage des antibiotiques chez les animaux de compagnie. Deuxième édition - September, Afvac. 2022:18-20/388pp.

Madec J-Y. L'antibiorésistance vue par les médecins et les vétérinaires : pourquoi un tel décalage de phase ? L'antibiorésistance. Un fait social total. In Harpet Claire, 2022:101-109, 168pp.

Maugat S, Berger-Carbonne A, Nion-Huang M et al. (2022) Prévention de la résistance aux antibiotiques - une démarche une seule santé. Santé publique France, pp.1-25.

https://www.santepubliquefrance.fr/content/download/538878/3931914?version=1

Oral communications and posters in congresses

Bourély C, Rousset L, Colomb-Cotinat M, Collineau L (2022) Why setting up One health Surveillance? A qualitative study exploring the drivers for collaboration between antimicrobial resistance surveillance programmes in France. *ECVPH AGM & Annual Scientific Conference*. Athène, Grèce, 28-30 September. Poster.

Collineau L, Bourély C, Rousset L, Colomb-Cotinat M (2022) Characterisation and mapping of the French surveillance system for antimicrobial resistance, antimicrobial use and antimicrobial residues in 2021. *4th International Conference on Animal Health Surveillance*. Copenhague, Danemark, 3-5 May. Communication orale.

Collineau L, Rousset L, Colomb Cotinat M, Bordier M, Bourély C (2022) Moving towards One Health surveillance of antimicrobial resistance in France : an evaluation of the level of collaboration within the surveillance system. *European Scientific Conference on Applied Infectious Disease Epidemiology*. Stockholm, Suède, 23-25 November. Poster.

Contarin R, Drapeau A, Haenni M, Dordet-Frisoni E (2022) Landscape of mobile genetic elements in *Staphylococcus aureus* of animal origin and their antibiotic resistance genes content. *International Symposium on Plasmid Biology (ISPB)*. Toulouse, France, 18-23 September. Poster.

Contarin R, Drapeau A, Haenni M, Dordet-Frisoni E (2022) Landscape of mobile genetic elements in *Staphylococcus aureus* of animal origin and their antibiotic resistance genes content. *17e Congrès National de la Société Française de Microbiologie (SFM)*. Montpellier, France, 3-5 October. Poster.

Coz, E, Jouy E, Cazeau G, Jarrige N, Perrin-Guyomard A, Hémonic A, Poissonnet A, Chanteperdrix M, Urban D, Chevance A, Delignette-Muller M-L and Chauvin C (2022) Assessment of the French colistin action plan. *AACTING third international conference*. Hannovre, Allemagne, 5-6 May. Poster.

Haenni M, Boulouis H-J, Lagrée A-C, Drapeau A, Va F et al. (2022) Transmission of clones and plasmids carrying resistances to critically important antibiotics within and between hospitalized dogs and their environment. *13th International Meeting on Microbial Epidemiological Markers (IMMEM)*. Bath, Angleterre, 14-17 September. Poster.

Lupo A, Valot B, Drapeau A, Saras E, Bour M et al. (2022) Phylogenetic and resistome analysis of epidemic multidrug-resistant Acinetobacter baumannii clone. *FEMS Conference on Microbiology*. Belgrade, Serbie, 30 June-2 July. Poster.

Madec J-Y. (2022) Biosécurité en hospitalisation : le cas des bactéries multi-résistantes aux antibiotiques. *50èmes journées de l'AVEF*. Reims, France, 10 November. Oral communication.

Madec J-Y. (2022) Problématique de l'antibiorésistance en santé animale. *7e séance du séminaire "Théorie et économie politique de l'Europe" organisé par le CEVIPOF et l'OFCE, Sciences Po*. Paris, France, 7 October. Oral communication.

Madec J-Y. (2022) Etats des lieux de l'antibiorésistance en santé animale. *Colloque Coopération Santé – Institut Curie*. Paris, France, 5 October. Oral communication.

Madec J-Y. (2022) L'antibiorésistance au prisme des biotechnologies. *Colloque Agrobiotech. Le rôle des biotech dans l'approche One Health – AgroParisTech*. Paris, France, 3 February. Oral communication.

Madec J-Y. (2022) Circulation et transmission de l'antibiorésistance dans le monde animal *Journée du Bicentenaire Louis Pasteur. Académie Nationale de Médecine*. Paris, France, 9 December. Oral communication.

Madec J-Y. (2022) Recent achievements in AMR in the animal domain in France. . *Antimicrobial symposium organized by the AMR Think-Do-Tank*. Genève, Suisse, 16 November. Oral communication.

Madec J-Y. (2022) AMR and environmentally related issues. *One Health EJP Annual scientific meeting*. Orvieto, Italie, 16 November. Oral communication.

Madec J-Y. (2022) Challenges related to the environmental dimension of AMR. International symposium "One substance – one assessment ? The next 20 years". *German Federal Institute for Risk Assessment*. Berlin, Allemagne, 3 November Oral communication.

Madec J-Y. (2022) Point d'actualité sur la colistine. *Journées Nationales des Groupements Techniques Vétérinaires*. Nantes, France, 19 May. Oral communication.

Madec J-Y. (2022) Suivi des résistances : un nouvel outil au service des praticiens. *Journées Nationales des Groupements Techniques Vétérinaires*. Nantes, France, 19 May. Oral communication..

Madec J-Y. (2022) La résistance aux antibiotiques en 2022 chez les animaux de compagnie. *Congrès annuel de l'AFVAC*. Marseille, France, Décember 1st. Oral communication.

Ncir S, Lupo A, Drapeau A, Châtre P, Souguir M et al. (2022) Retour au progéniteur : $bla_{OXA\text{-}204}$ et $bla_{NDM\text{-}1}$ chez des *Shewanella* spp. en Tunisie. *17e Congrès National de la Société Française de Microbiologie (SFM)*. Montpellier, France, 3-5 October. Poster.

Rousset L, Collineau L, Bourély C, Colomb-Cotinat M (2022) Vers une approche One Health de la surveillance de l'antibiorésistance et des usages d'antibiotiques en France. *23ème Journées Nationales d'Infectiologie*. Bordeaux, France, 15-17 June. Communication orale.

Tegegne HT, Bogaardt C, Collineau L, Lailler R, Cazeau G et al. (2022) OH-EpiCap : a semi quantitative tool for the evaluation of One Health surveillance capacities and capabilities. *4th International Conference on Animal Health Surveillance*. Copenhague, Danemark, 3-5 May. Poster.

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