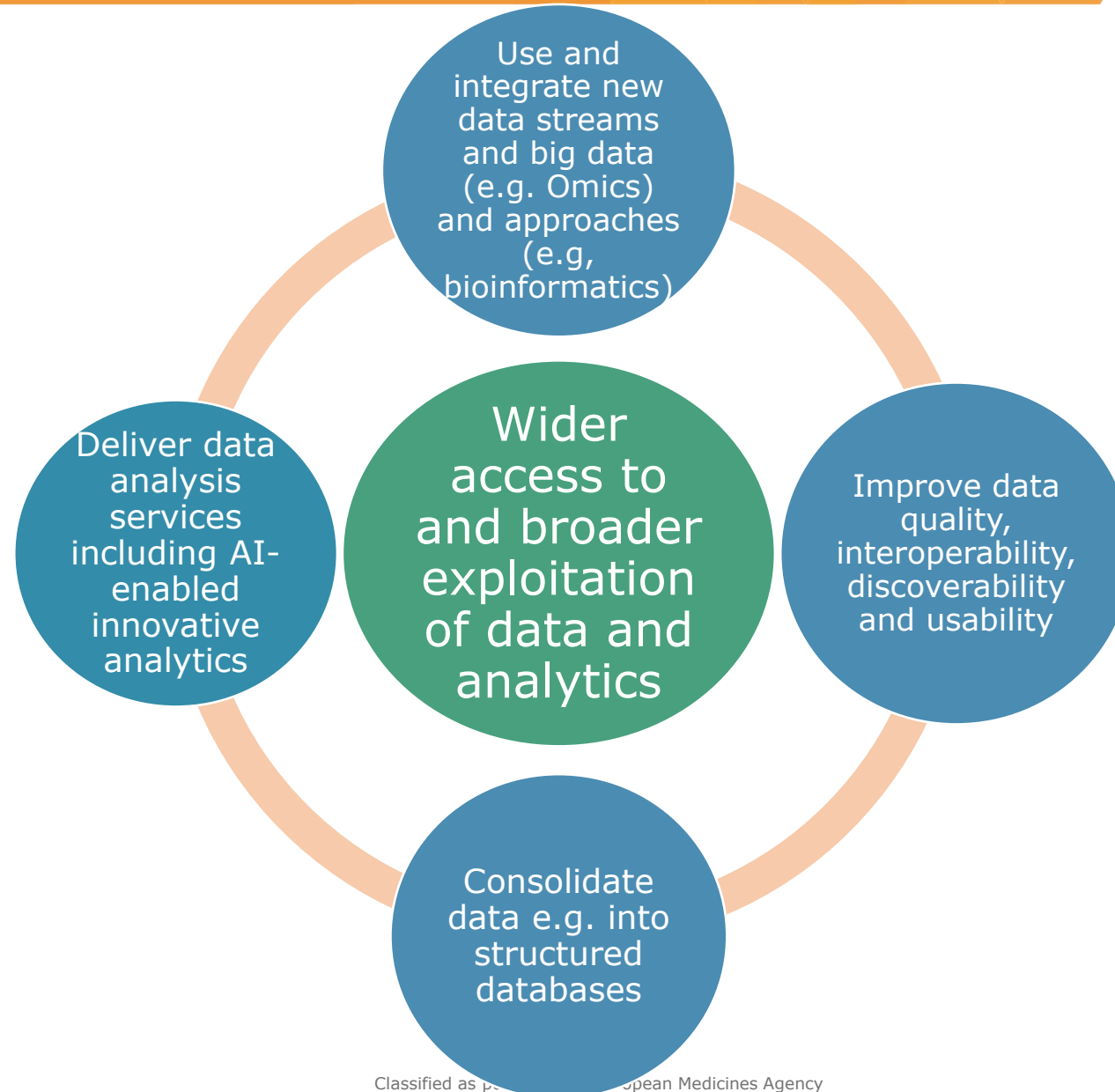




Current and future use of omics and other data in food/feed safety assessments

Konstantinos Paraskevopoulos (Chief Scientist Office) & **Mirko Rossi** (BIOHAW)

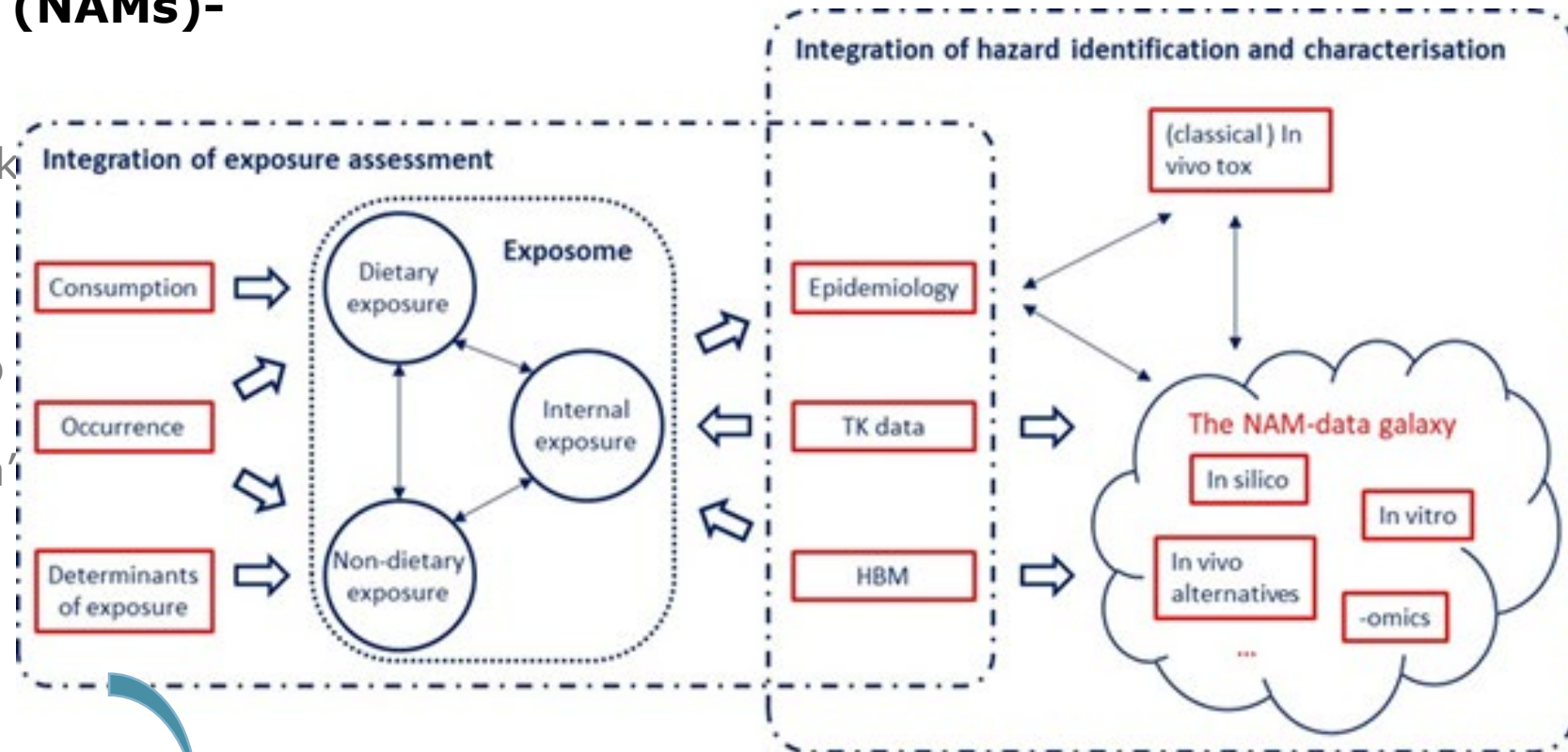
Trusted science for safe food



Chemical Risk Assessment - a vision for the coming years- EFSA NAMs roadmap for action

New Approach Methodologies (NAMs)- Non animal-based methods

- NAM-based, mechanistic-based risk assessments for chemicals in food and feed (**EMA's regulatory science strategy 2025**)
- *In vitro* and *in silico* alternatives to animal testing, connected to modern technologies and "big data"



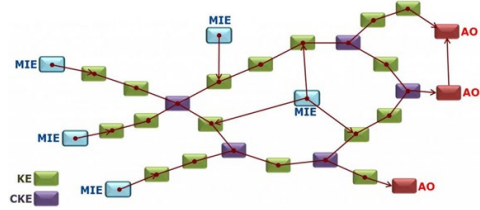
Roadmap on Advancing Aggregate Exposure to Chemicals in EU (e.g. explore data generation / connection / collection and tool development in collaboration with sister agencies (EMA, ECHA, EEA))

Risk characterisation

NAM-based Integrated Assessment and Testing Strategies (IATAs)

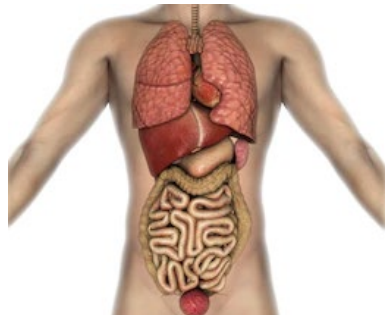
Six Prioritised Scientific Areas Requiring Further Scientific Development for NAMs

AOPs/AOP networks

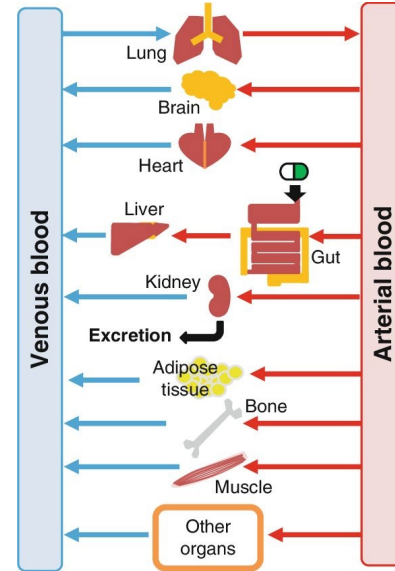


Adverse Outcome Pathways e.g. for developmental neurotoxicity

Advanced cell culture systems and OoCs



IVIVE-PBK



Develop advanced *in vitro/in silico* ADME models/databases

Exposome



Data integration



- Develop NAMs data Integration approaches
- AI4NAMS: AI based data search, extraction, harmonisation and integration

Susceptible human population



A roadmap for action: OMICS & Bioinformatics Approaches: Next Generation Risk Assessment

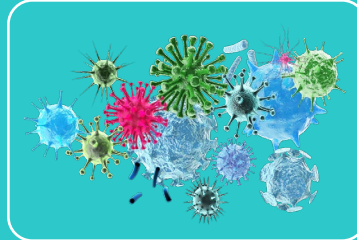
By 2030, EFSA will integrate **omics and associated bioinformatic approaches in its RAs** allowing for an enhanced food chain analytics

- Address challenges (e.g.):
 - Data generation, collection and storage
 - Implementation of the FAIR principles for data
 - Implementation of robust bioinformatic analytical tools and their validation



Improve/facilitate the use of WGS analysis, e.g.:

- In currently applied areas (e.g. foodborne outbreak, AMR monitoring)
- Extend to other areas (e.g. animal/plant health)



Incorporate use of metagenomics into RA for animal, human and environmental health, e.g.:

- Assessment of food additives or novel foods on **human/animal and environmental microbiome**
- Impact of pesticides on biodiversity (bacterial soil communities)



Incorporate other Omics (transcriptomics metabolomics, proteomics, etc) for e.g.:

- Improved assessments of complex products (e.g. Synbio/allergenicity)
- Identify novel biomarkers for the mass screening of contaminants, nutrients, exposures
- Develop methodologies for integrated analysis of multiple omics datasets

Tox pathway analysis to predict target organ toxicity

Inference of Chemical Grouping from Processed OMICS Data

Implementation of a Multi-OMICS and Inter-species Workflow using Quantitative in Vitro Data

WGS applied to foodborne outbreak



- Whole genome sequencing analysis of foodborne pathogens is keystone in outbreak investigation for identifying variants causing the outbreak
- Its application resulted in significant health benefits
 - in US is estimated annually at nearly \$500 million, compared to an approximately \$22 million investment by public health agencies
- Main challenges for its effective applications
 - Cross-sectoral interaction
 - WGS data comparability
 - Timely data availability
 - Political barriers in data sharing

Strategic elements identified by EFSA

Towards WGS-based molecular typing data collection in EFSA

- In 2017, first joint EC mandate for a feasibility study on the collection and analysis of **Whole Genome Sequencing (WGS) data** from foodborne pathogens from human and non-human isolates

TECHNICAL REPORT

APPROVED: 29 April 2019

doi:10.2903/sp.efsa.2019.EN-1337



<https://www.efsa.europa.eu/en/supporting/pub/en-1337>



IT architecture



Transparency



Engagement



Data Ownership



Data confidentiality

- In 2019, EFSA and ECDC received a follow up mandate for **implementing and managing a One Health system** for the collection and joint analysis of **WGS data** from foodborne isolates from human, food, feed, animal and environmental samples

Requirement from the requestor



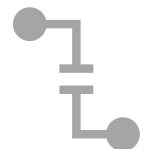
Interoperability of the two systems in the public health and the food safety sectors

- Detection of **joint microbiological clusters of human and non-human food-borne pathogens isolates**
- **Data exchange on demand** when matches have been found
- Automatic **exchange of WGS-based typing data and epidemiological data** between the two systems

The EFSA One Health WGS System



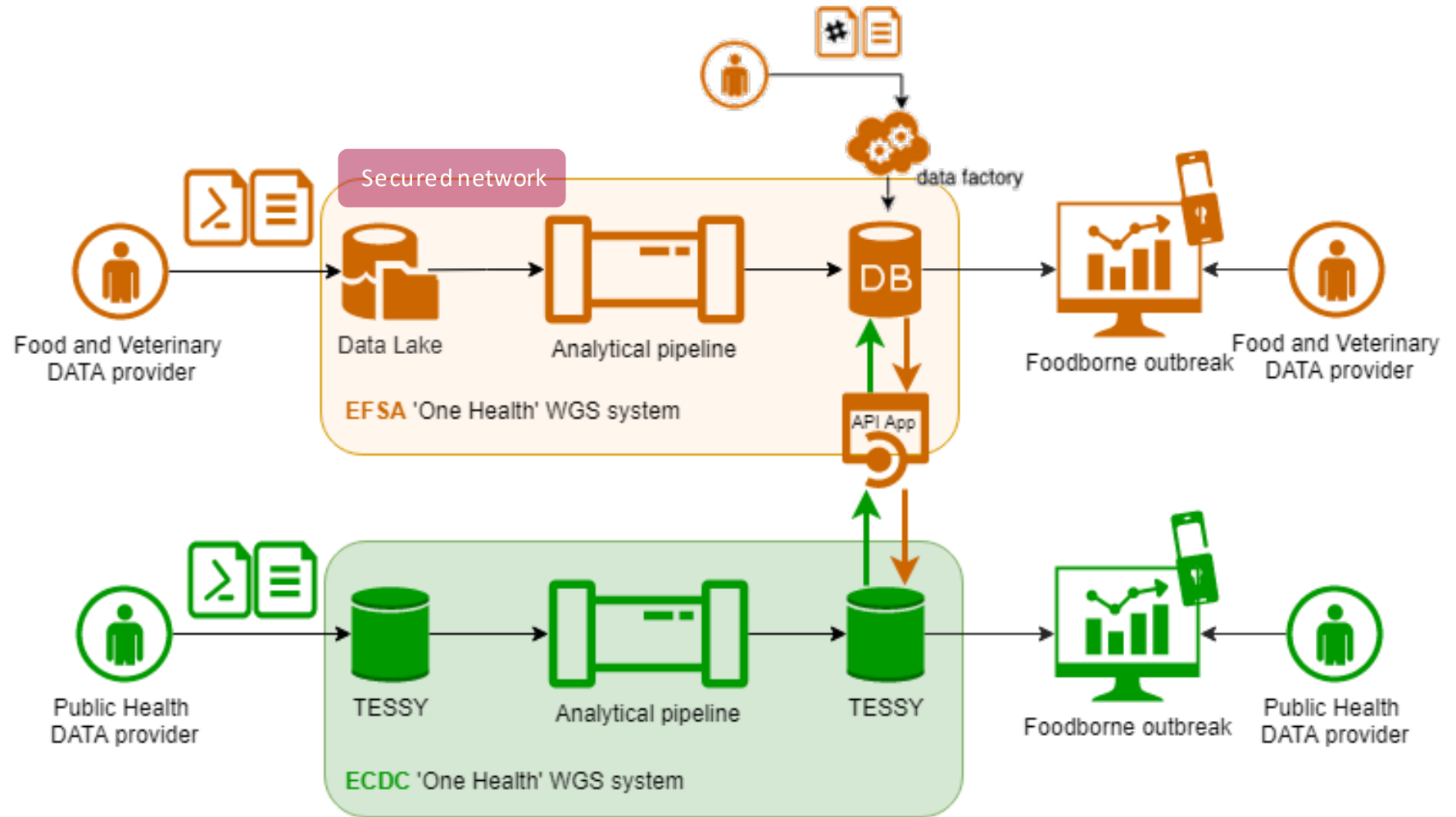
Interoperability



Cross-sector matches

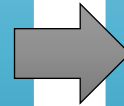


Machine-to-machine



Objective of the EFSA One Health WGS System

To collect **genomic profile of foodborne pathogens and associated epidemiological data** of isolates from food, feed, animals and related environment



Build a database of genome profiles that can be queried in case of food-borne outbreaks
EU/EEA countries are invited to submit WGS-based typing data on a voluntary basis at any time throughout the year

To **allow ECDC to query the EFSA database** for finding possible matches between human and non-human isolates



Support the real-time investigation of multi-country food-borne outbreaks

To offer a **set of services through a user-friendly interface** for the analysis and managing of the submitted data

Type of data collected



Experimental data: information related to the experiment (*raw sequencing reads*)



Typing data: genomic profile and other typing data extracted from the raw sequencing reads



Epidemiological data: information related to the food, feed and animal samples from which the pathogen isolates linked to genomic profiles originated

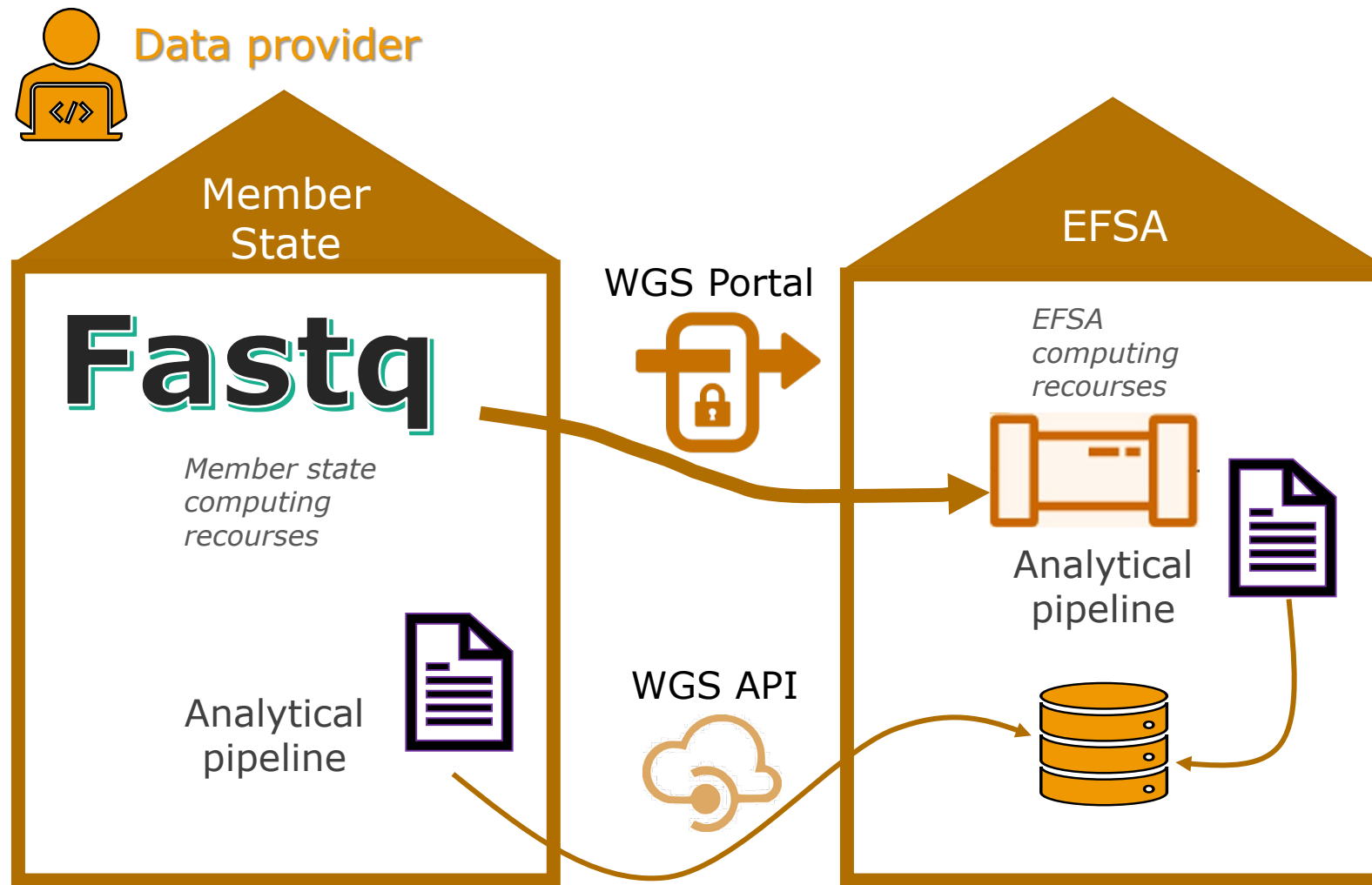
Fastq



Analytical pipeline



Move code as alternative of moving big data



Other examples of digital data in EFSA One Health assessments



New communication & data visualisation online tools: EFSA story map and dashboard on foodborne outbreaks

EFSA's story map on foodborne outbreaks

<https://multimedia.efsa.europa.eu/fbo-storymaps/index.html>

Foodborne Outbreaks
Updated last on 11.30.2021

List of Contents

- What foodborne outbreaks are and how they are classified
- What foods may cause foodborne outbreaks
- What organisms and symptoms
- How, why and where food contamination may occur
- Who investigates foodborne outbreaks
- How many foodborne outbreaks in 2020
- What is the real burden on public health
- How to protect yourself from foodborne illness
- EU regulatory framework and the role of EFSA
- References and further reading on this topic

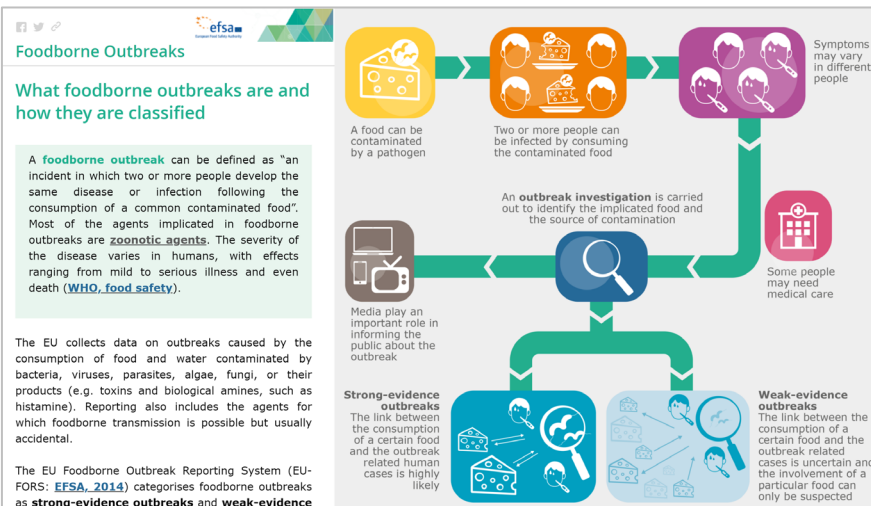
Foodborne Outbreaks

What foodborne outbreaks are and how they are classified

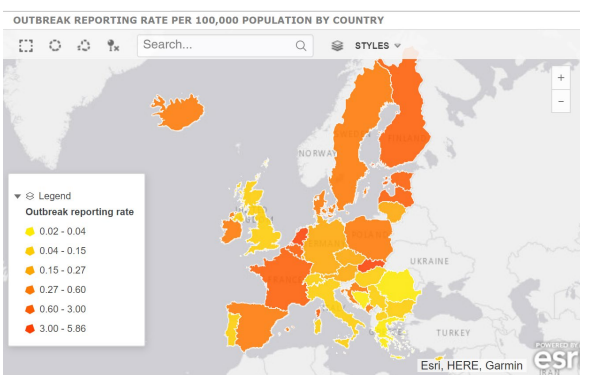
A foodborne outbreak can be defined as "an incident in which two or more people develop the same disease or infection following the consumption of a common contaminated food". Most of the agents implicated in foodborne outbreaks are zoonotic agents. The severity of the disease varies in humans, with effects ranging from mild to serious illness and even death (WHO, food safety).

The EU collects data on outbreaks caused by the consumption of food and water contaminated by bacteria, viruses, parasites, algae, fungi, or their products (e.g. toxins and biological amines, such as histamine). Reporting also includes the agents for which foodborne transmission is possible but usually accidental.

The EU Foodborne Outbreak Reporting System (EU-FORS: EFSA, 2014) categorises foodborne outbreaks as strong-evidence outbreaks and weak-evidence



EFSA's dashboard on foodborne outbreaks



Foodborne outbreaks - dashboard
CAUSATIVE AGENTS

Reporting year: 2020

Strength of evidence: (All)

Type of outbreak: (All)

EU and non EU: (All)

Reporting country: (All)

Number of countries: 33

Outbreaks: 3,143

Cases: 21,513

Hospitalisations: 1,830

Deaths: 48

NUMBER OF OUTBREAKS BY CAUSATIVE AGENT

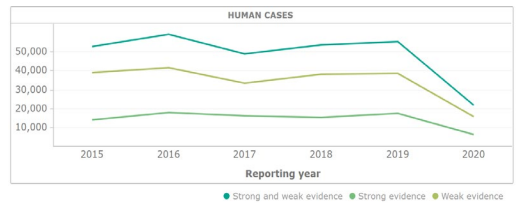
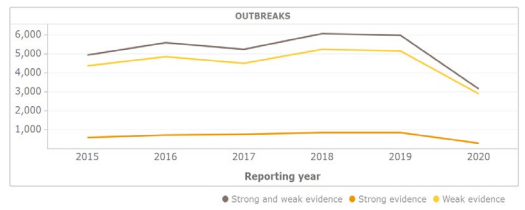
Unknown / Unspecified	1,244
Salmonella	708
Bacterial toxins unspecified	372
Campylobacter	322
norovirus and other Calicivirus	132
Bacillus toxins	72
Staphylococcus aureus toxins	44
Histamine and Scombrotoxin	43
STEC	41
Clostridium perfringens	36
Marine biotoxins	23
Listeria monocytogenes	20
Other viruses	18
Yersinia	16
Other bacterial agents	15
Clostridium botulinum	19
Trichinellosis	9
Hepatitis A	7
Other parasites	5
Cryptosporidium	4
Other agents	3
Brucella	1

NUMBER OF HUMAN CASES AND HOSPITALISATIONS BY CAUSATIVE AGENT

Salmonella	4,527
Bacterial toxins unspecified	2,813
Bacillus toxins	2,564
Staphylococcus aureus toxins	1,354
Other bacterial agents	772
Yersinia	412
Other viruses	301
Trichinellosis	251
Other parasites	225
Other agents	179
Rinvelis	134

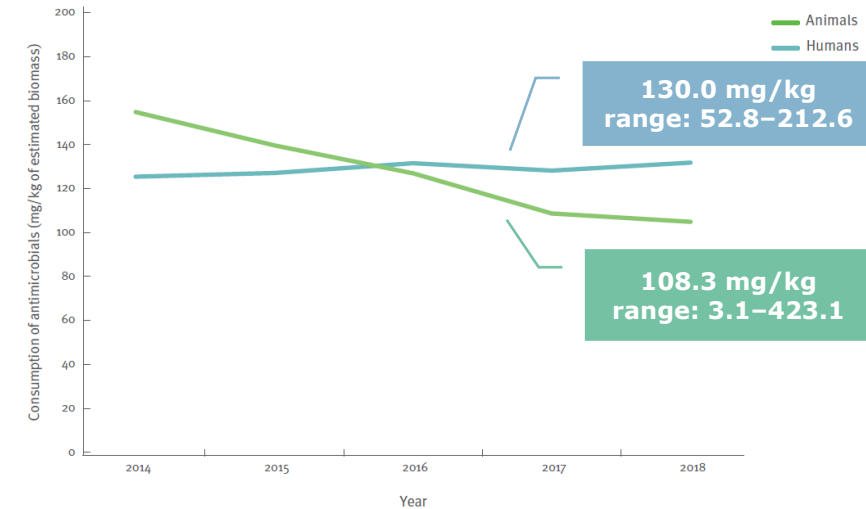
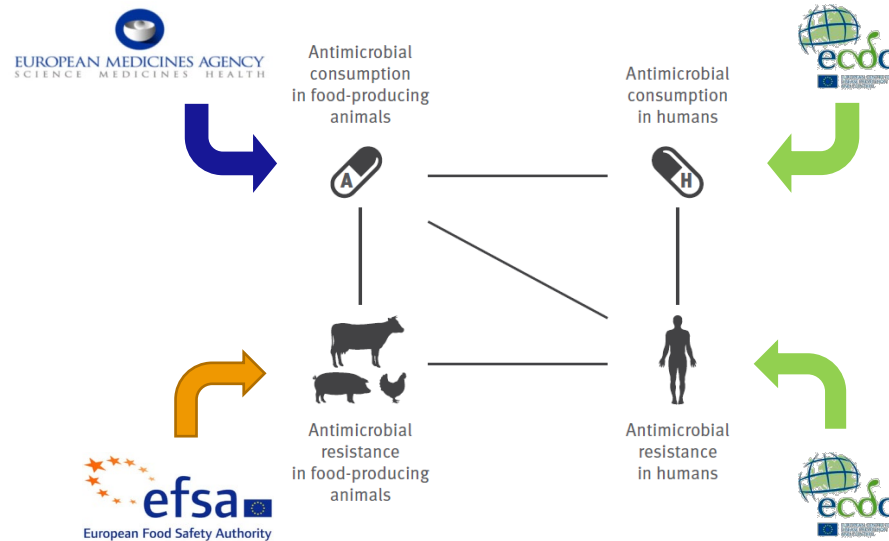
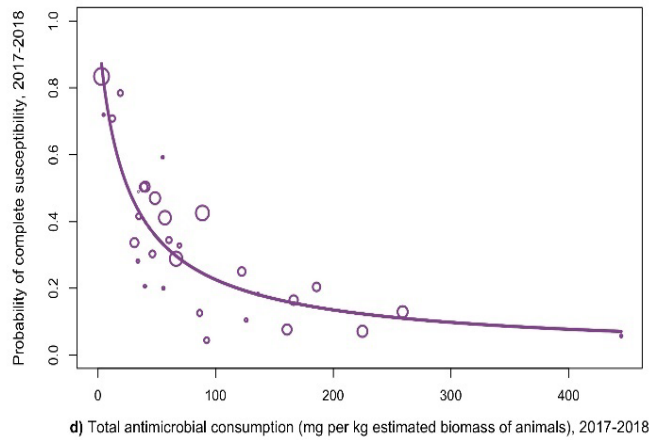
DISTRIBUTION (% OF DEATHS BY CAUSATIVE AGENTS)

STEC (2.08%)
Salmonella (16.67%)
norovirus and other Calicivirus (2.08%)
Bacillus toxins (2.08%)
Histamine and Scombrotoxin (2.08%)
Listeria monocytogenes (52.50%)



<https://www.efsa.europa.eu/en/microstrategy/FBO-dashboard>

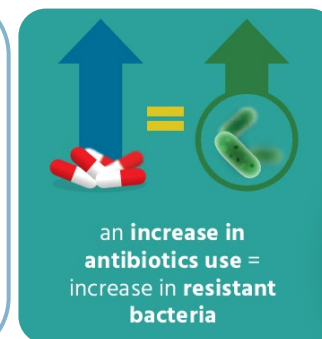
JIACRA: integrated analysis of Ab consumption and AMR



A consistently **lower probability** of detecting completely susceptible indicator *E. coli* in animals when AMC was higher

Overall Conclusions

- Interventions to **reduce AMC** will have a **beneficial impact** on **AMR**
- Need to promote, in both humans and food-producing animals:
 - ✓ **prudent use** of antimicrobial agents
 - ✓ **infection prevention and control**
- High levels of AMC and AMR still reported: **interventions to be reinforced**





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