

# Integrating genomic data into surveillance and multi-country outbreak investigations: EU strategy implementation

Marc Struelens, Vicky Lefevre, ECDC

9<sup>th</sup> Seminar of National Reference Centres, Paris, 15 November 2019

## MEETING REPORTS

# Molecular epidemiology of human pathogens: how to translate breakthroughs into public health practice, Stockholm, November 2011

D Palm<sup>1</sup>, K Johansson<sup>1</sup>, A Ozin<sup>1</sup>, A W Friedrich<sup>2</sup>, H Grundmann<sup>2</sup>, J T Larsson<sup>3</sup>, M J Struelens (marc.struelens@ecdc.europa.eu)<sup>1</sup>

1. European Centre for Disease Prevention and Control (ECDC), Stockholm, Sweden
2. University Medical Centre Groningen, University of Groningen, Groningen, the Netherlands
3. Statens Serum Institut, Copenhagen, Denmark



## MEETING REPORT

### ECDC technical consultation on harnessing genomics for epidemiological surveillance

Paris, 1–2 October 2013

# Whole Genome Sequencing: ECDC Vision 2020

- To establish standards and manage systems
- EU wide use of whole genome sequencing as the method of choice for typing microbial pathogens
- Accurate and effective risk assessment, outbreak investigation, disease surveillance and evaluation of prevention policies

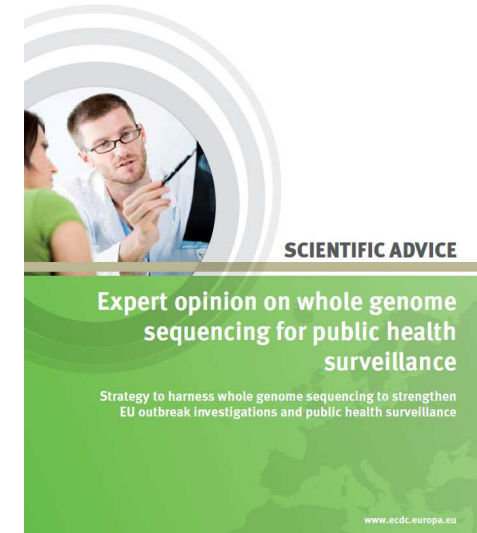
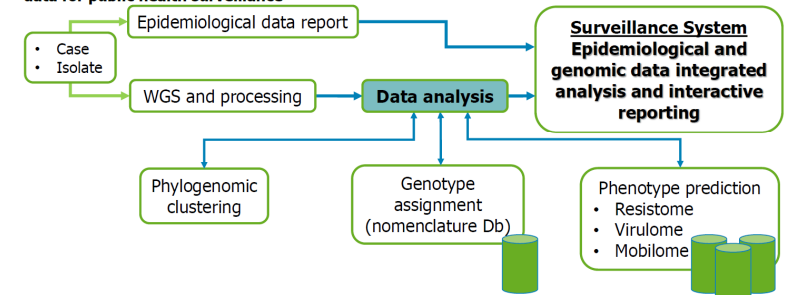


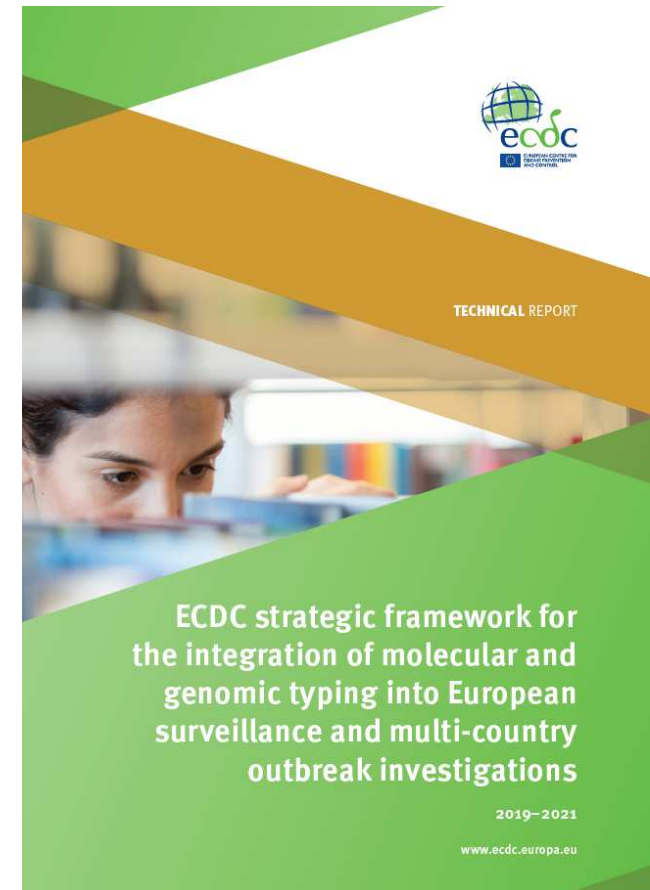
Figure 2. Process overview – WGS data production, analysis and integration with epidemiological data for public health surveillance



# Whole Genome Sequencing: Strategic framework 2021



- **Priorities for integration into EU surveillance and response support systems, 2019-2021**



# Public health applications of integrated epidemiological and WGS data collection and analysis



- 1. Outbreak investigations:** real-time information sharing and analysis for *rapid risk assessment*, targeted public health response and transmission control
- 2. Control-oriented surveillance:** real-time, continuous surveillance with maximal disease sampling frame for *early outbreak detection*
- 3. Strategy-oriented surveillance:** either by *sentinel continuous surveillance* or *periodic surveys*, with representative sampling frame for programme evaluation and trend monitoring

# Priority criteria for integrating genomic typing data into EU epidemiological investigations



- Disease **public health priority** and added-value of WGS data for infection control
- **Feasibility** of standardised typing schemes and data sharing
- **Capacity** for WGS typing at Member State and ECDC level
- **Interoperability** with information systems of public health partners at EU and international levels

# WGS capacity in public health reference laboratories

## EU-EEA NMFP surveys, 2015-2017



### Objectives

- Monitor national arrangements and capacities for WGS use
- Inform the implementation of ECDC genomic surveillance roadmap
- Identify the areas where ECDC can foster capacity

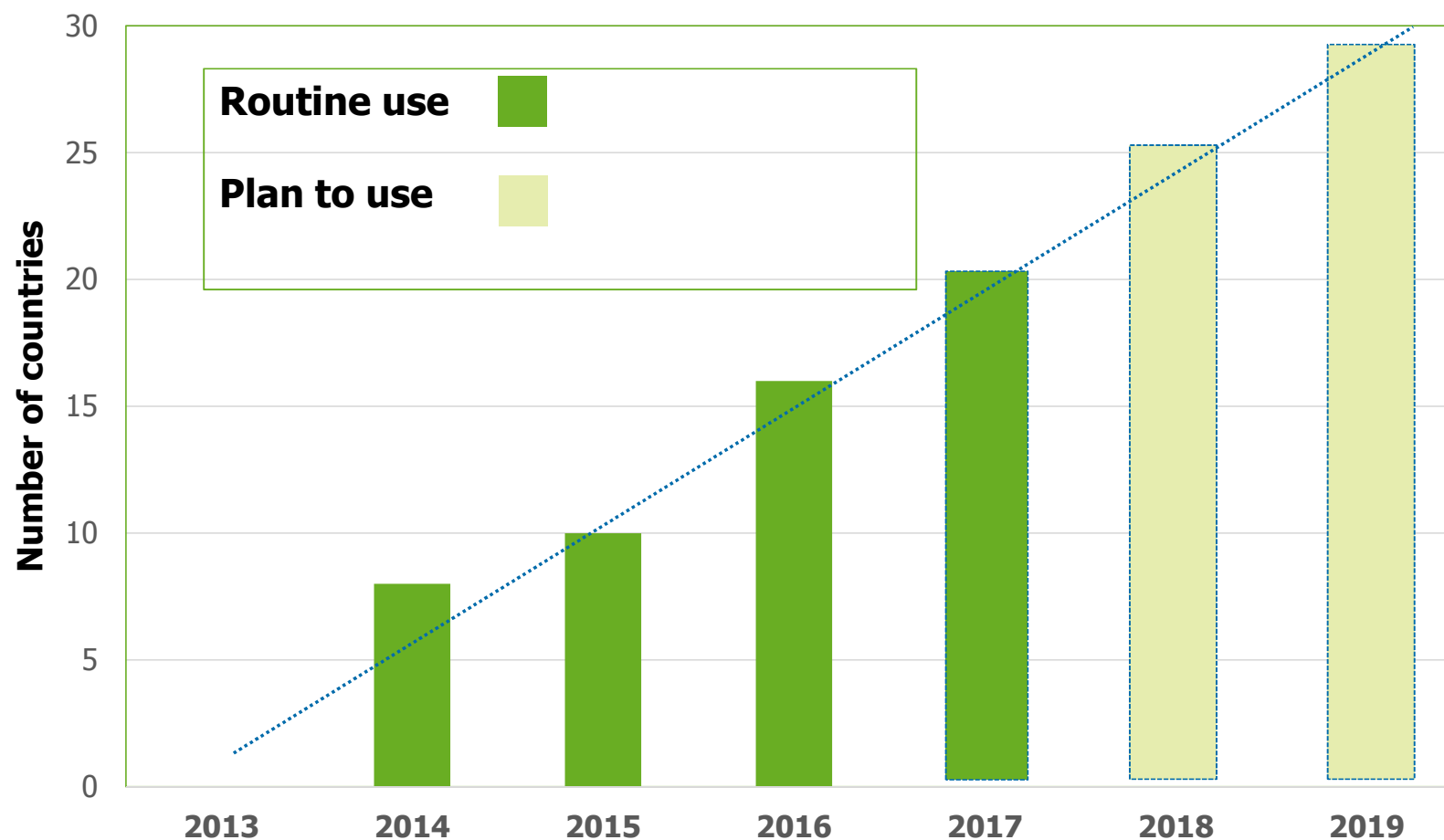
### Scope

- Planned/actual use of WGS for national surveillance and outbreak investigations
- NGS platforms and bioinformatics pipelines

### Methods

- Online surveys by the National Microbiology Focal Points on national reference laboratories routine use in 2015, 2016 and 2017

# WGS-based typing used for national surveillance, EU/EEA, 2013-2019



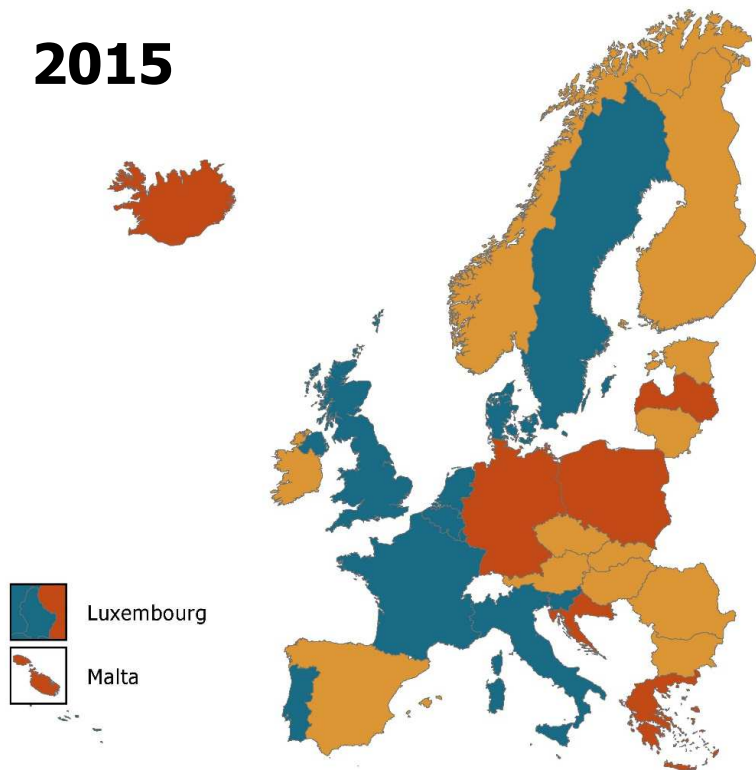
**Source:** ECDC NMFP surveys 2013-17 (n=30 EU/EEA countries).



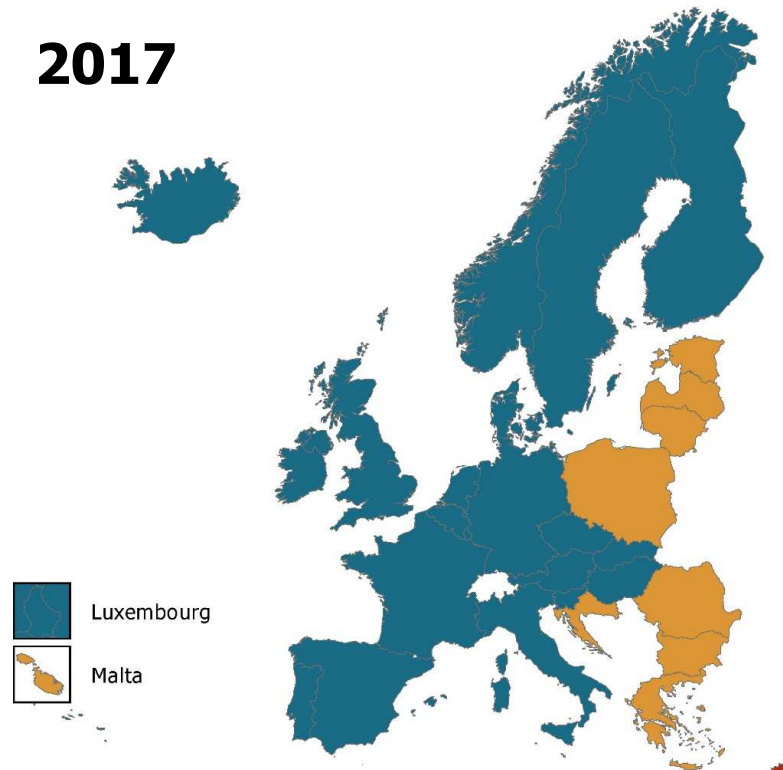
# Expansion of WGS-based typing use in national public health reference laboratories



2015



2017



- WGS-based typing used routinely for national surveillance** of at least 1 human pathogen
- Not used for public health operations but planned by 2019
- Not planned to implement within 3 years

Monitoring use of Whole-Genome Sequencing for infectious diseases surveillance in the European Union and European Economic Area, 2015-2017.  
Stockholm: ECDC; 2018

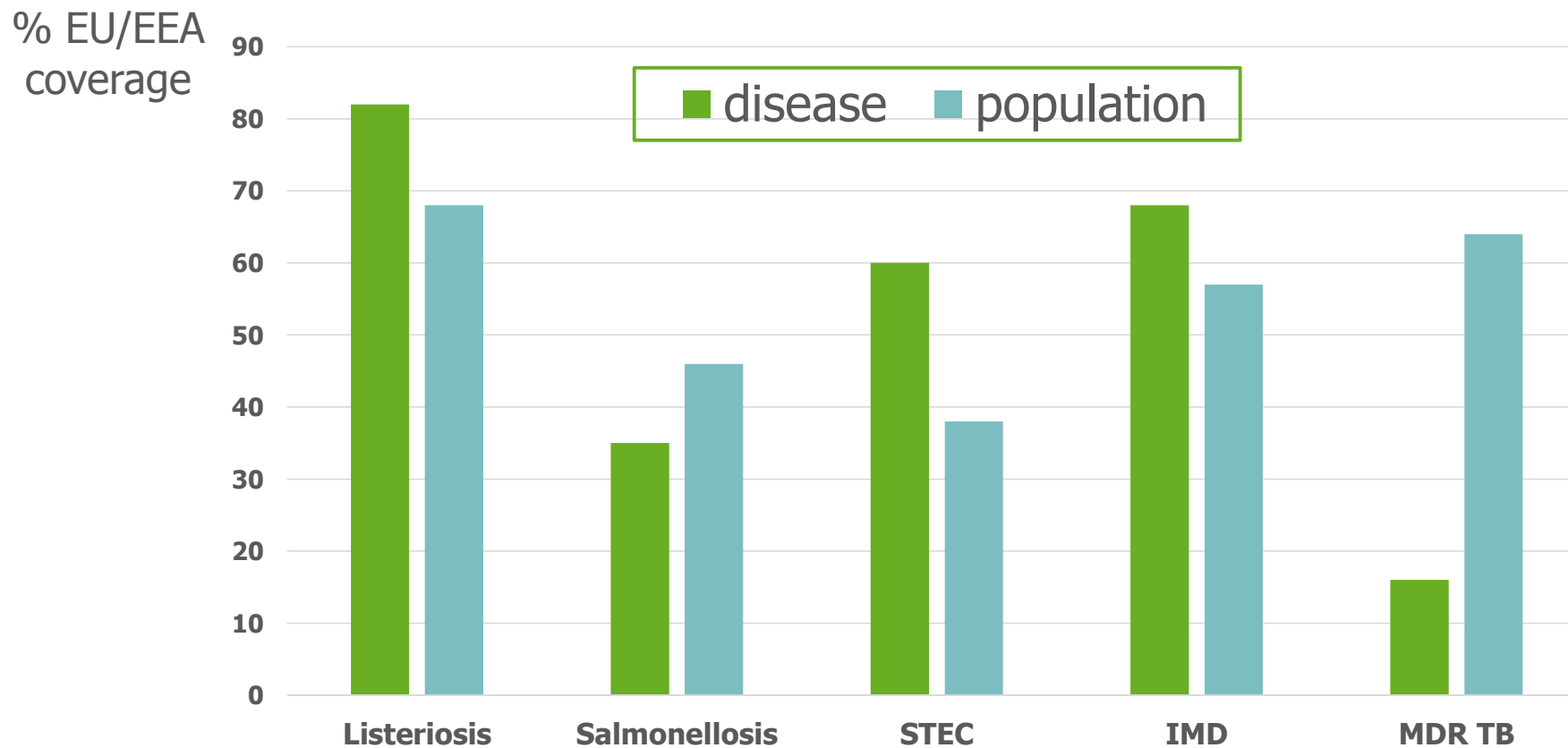
# Public health genomics workshop, 23-24 October 2019



- Topics:
  - Basic concepts and methods of public health genomics
  - Integrated analysis and visualisation of WGS and epidemiological data
  - Multidisciplinary interpretation of results to inform disease control
- 20 participants from 12 countries: Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Germany, Greece, Latvia, Lithuania, Malta, Poland and Romania



# EU coverage of genomic surveillance, 2017

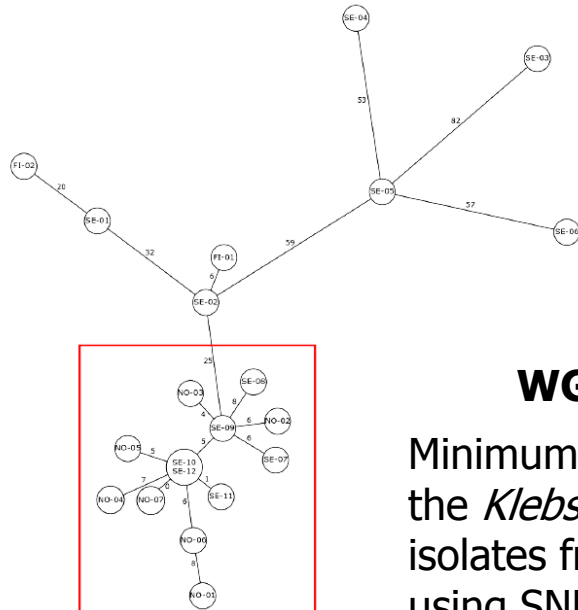


# WGS typing: EU Strategic priorities 2021, by objective



<b>Outbreak investigation</b>
Any epidemic pathogen/MDR outbreak
<b>Continuous real-time surveillance</b>
<ul style="list-style-type: none"><li>• <i>Listeria monocytogenes</i></li><li>• <i>Neisseria meningitidis</i></li><li>• MDR tuberculosis</li><li>• <i>Salmonella enterica</i></li><li>• Shiga toxin <i>E.coli</i></li><li>• influenza virus</li></ul>
<b>Sentinel surveys</b>
<ul style="list-style-type: none"><li>• Carbapenem/ colistin-resistant <i>Enterobacteriaceae</i></li><li>• Antibiotic-resistant <i>Neisseria gonorrhoeae</i></li><li>• Carbapenem-resistant <i>Acinetobacter baumannii</i></li><li>• <i>Bordetella pertussis</i></li><li>• <i>Streptococcus pneumoniae</i></li></ul>

# Multi-country outbreaks of carbapenemase-producing *Klebsiella pneumoniae*: cooperative WGS investigations



## WGS analysis

Minimum spanning tree showing the *Klebsiella pneumoniae* ST392 isolates from 2015-2018 analysed using SNPs (Public Health Agency of Sweden). The red box indicates the current outbreak cluster including 13 Swedish and Norwegian cases. Isolates (top right) are epidemiologically unrelated control isolates of *K. pneumoniae* ST392.



RAPID RISK ASSESSMENT

Carbapenemase-producing (OXA-48) *Klebsiella pneumoniae* ST392 in travellers previously hospitalised in Gran Canaria, Spain

10 July 2018



RAPID RISK ASSESSMENT

Outbreak of carbapenemase-producing (NDM-1 and OXA-48) and colistin-resistant *Klebsiella pneumoniae* ST307, north-east Germany, 2019

28 October 2019

# European Antimicrobial Resistance Genes Surveillance Network (EURGen-Net)

## Networks and partnerships



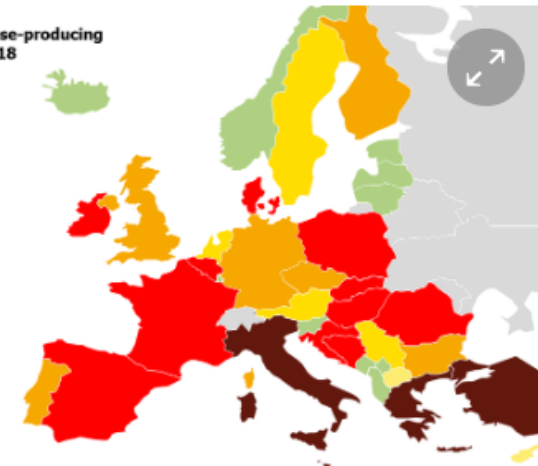
The European Antimicrobial Resistance Genes Surveillance Network (EURGen-Net) is a network for genomic-based surveillance of multidrug-resistant bacteria of public health importance, coordinated by the European Centre for Disease Prevention and Control (ECDC). National reference laboratories or equivalent laboratories of 37 European countries currently participate in EURGen-Net.

The public health objectives of this European whole genome sequencing (WGS)-based surveillance are to determine the geographic distribution and population dynamics of multidrug-resistant clones and transmissible resistance elements to inform risk assessment, prevention and control policies and to support countries in developing technical capability and proficiency for genomic-based surveillance of multidrug-resistant bacteria with epidemic potential.

Spread of carbapenemase-producing Enterobacteriaceae, 2018



Source: Brokd et al. Eurosurveillance 2018



27 October 2016

### Multi-country Salmonella outbreak



Seven countries have reported human cases of *Salmonella* Ent and 12 October 2016 (112 confirmed and 148 probable).

Cases have been reported by Belgium, Denmark, Luxembourg

Print

Twitter

LinkedIn

Facebook

# EU Multi-country Foodborne outbreaks



## E. coli cucumber scare: Spain angry at German claims

31 May 2011

EHEC O104:H4 Outbreak in Germany, 2011



France

### Lactalis to withdraw 12m boxes of baby milk in salmonella scandal

Emmanuel Besnier, chief executive of French dairy products from contaminated factory will be recalled

Kim Willsher in Paris

Sun 14 Jan 2018 16:03 GMT

This article is over 9 months old



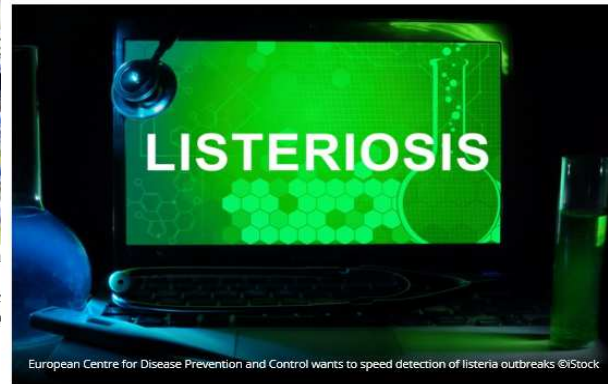
A French government official checks baby milk products in a pharmacy in Or Souvant/AFP/Getty Images

The head of a French dairy giant at the centre of an ir scandal has promised to withdraw 12m boxes of pow the supermarket shelves of 83 countries.

### 'Most outbreaks remain undetected': How the EU is strengthening listeriosis surveillance

By Katy Askew 22-Aug-2018 - Last updated on 22-Aug-2018 at 14:16 GMT

12



European Centre for Disease Prevention and Control wants to speed detection of listeria outbreaks ©iStock

### Swedes get hepatitis A from eating infected frozen strawberries



File photo of frozen strawberries. Photo: Bertil Enevåg Ericson/TT

Swedes have been reminded not to eat frozen strawberries without properly heating them up first, after 13 people contracted hepatitis A from imported fruit.

### EFSA and ECDC re egg, sesame seed S

By Joe Whitworth on September 26, 2018

More detail has emerged about two pa in Europe.

One was caused by Salmonella Enteriti Poland and the other by a previously u imported sesame seeds.

# Joint Molecular Typing for Enhanced Surveillance

STEC O104:H4 outbreak

Collaboration agreement: ECDC-EFSA- EURLs for *Listeria monocytogenes*, *Salmonella* and VTEC => PFGE and MLVA

EC vision on molecular typing support for outbreak preparedness

EC request to ECDC and EFSA on establishment of molecular typing databases

Joint ECDC-EFSA Steering Committee for a joint molecular typing database

EC request to ECDC and EFSA to upgrade joint molecular typing database with WGS

First non-human isolate submitted to the joint database (PFGE)

First joint cluster detections PFGE and MLVA



ECDC pilot molecular typing data collection PFGE and MLVA

Pilot study WGS *Listeria*

EU-wide validation study *Listeria* WGS

1st WGS support to multi-country outbreak investigation

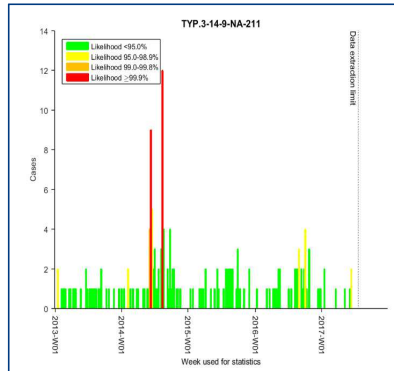
Upgrade Tessa database WGS





# WGS Improved Signal Detection and Response to Multi-Country Foodborne Outbreaks

MLVA<sup>1</sup> + PFGE<sup>2</sup>



Weekly cluster reports

Clusters of rare/new genotype <sup>1/</sup>					
HTCC	Pathogen	Countries	Size and method	Pattern	
HTCC-011	Salmonella enteritidis	AT, NL	1 @	PFGE	Age 025, Age 050
HTCC-041	Salmonella enteritidis	DK, NL, NO	1 @	HVA	817-3-4-1
HTCC-042	Salmonella enteritidis	DK, NL, NO, UK	1 @	HVA	817-3-3-2-1
HTCC-043	Salmonella enteritidis	DK, NO, UK	1 @	HVA	817-3-3-4-1
HTCC-044	Salmonella enteritidis	DK, UK	1 @	HVA	817-3-3-4-2
HTCC-045	Salmonella enteritidis	DK, NO, UK	1 @	HVA	817-3-3-4-3
HTCC-046	Salmonella enteritidis	DK, UK	1 @	HVA	817-3-3-4-4
HTCC-047	Salmonella enteritidis	DK, NO	1 @	HVA	817-3-3-4-1
HTCC-048	Salmonella enteritidis	NO, UK	1 @	PFGE	2-1-2-3-2
HTCC-049	Salmonella enteritidis	DK, UK	1 @	HVA	817-3-3-4-1
HTCC-050	Salmonella enteritidis	NO, UK	1 @	HVA	817-3-3-4-1

Clusters of common genotype <sup>1/</sup>					
HTCC	Pathogen	Countries	Size and method	Pattern	
HTCC-041	Salmonella Typhimurium	DK, NL, SE	22 @	HVA	TR-2-4-10-NA-211
HTCC-042	Salmonella enteritidis	DK, LU, NL, NO, UK	10 @	HVA	817-3-3-4-1
HTCC-043	Salmonella enteritidis	DK, LU, NL, NO, UK	22 @	HVA	817-3-3-4-1
HTCC-044	Salmonella enteritidis	DK, LU, NL, NO, UK	22 @	HVA	817-3-3-4-1
HTCC-045	Salmonella enteritidis	DK, LU, NL, NO, UK	22 @	HVA	817-3-3-4-1
HTCC-046	Salmonella Typhimurium	DK, LU, NL, SE	17 @	HVA	TR-2-4-10-NA-211

Small clusters of common genotype <sup>1/</sup>					
HTCC	Pathogen	Countries	Size and method	Pattern	
HTCC-047	Salmonella Typhimurium	NL, SE, UK	8 @	HVA	TR-2-4-10-NA-211
HTCC-048	Salmonella Typhimurium	NL, SE, UK	8 @	HVA	TR-2-4-10-NA-211
HTCC-049	Salmonella Typhimurium	DK, NL, SE	7 @	HVA	TR-2-4-10-NA-211
HTCC-050	Salmonella Typhimurium	DK, SE	2 @	HVA	TR-2-4-10-NA-211

Endemic clusters <sup>1/</sup>					
HTCC	Pathogen	Countries	Size and method	Pattern	
HTCC-041	Salmonella Typhimurium	DK, SE, NL, LU, NL, UK	75 @	HVA	TR-2-4-10-NA-211
HTCC-042	Salmonella Typhimurium	DK, SE, NL, LU, NL, UK	207 @	HVA	TR-2-4-10-NA-211
HTCC-043	Salmonella Typhimurium	DK, SE, NL, LU, NL, UK	191 @	HVA	TR-2-4-10-NA-211
HTCC-044	Salmonella Typhimurium	DK, SE, NL, LU, NL, UK	324 @	HVA	TR-2-4-10-NA-211
HTCC-045	Salmonella Typhimurium	DK, SE, NL, LU, NL, UK	333 @	HVA	TR-2-4-10-NA-211
HTCC-046	Salmonella Typhimurium	DK, SE, NL, LU, NL, UK	41 @	HVA	TR-2-4-10-NA-211

ECDC Extranet | EPIS FWD

**Urgent Inquiry:**  
unusual increase of cases at national level

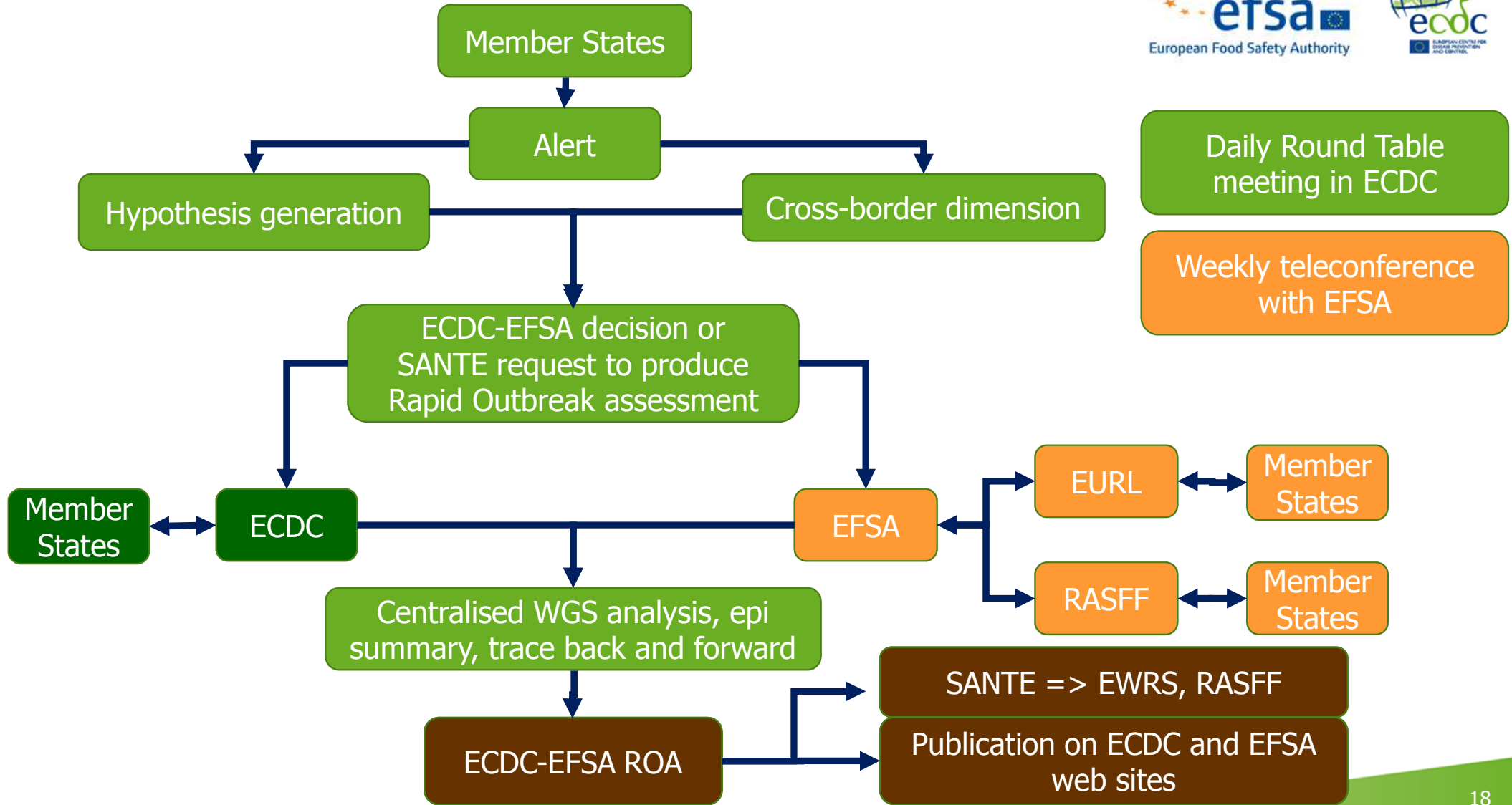
**Whole genome sequencing support since 2015**

Joint ECDC-EFSA Rapid Outbreak Assessments



<sup>1</sup>MLVA=Multi-Locus Variable number tandem repeat Analysis  
<sup>2</sup>PFGE=Pulsed-field gel electrophoresis

# Operational steps in Rapid Outbreak Assessment

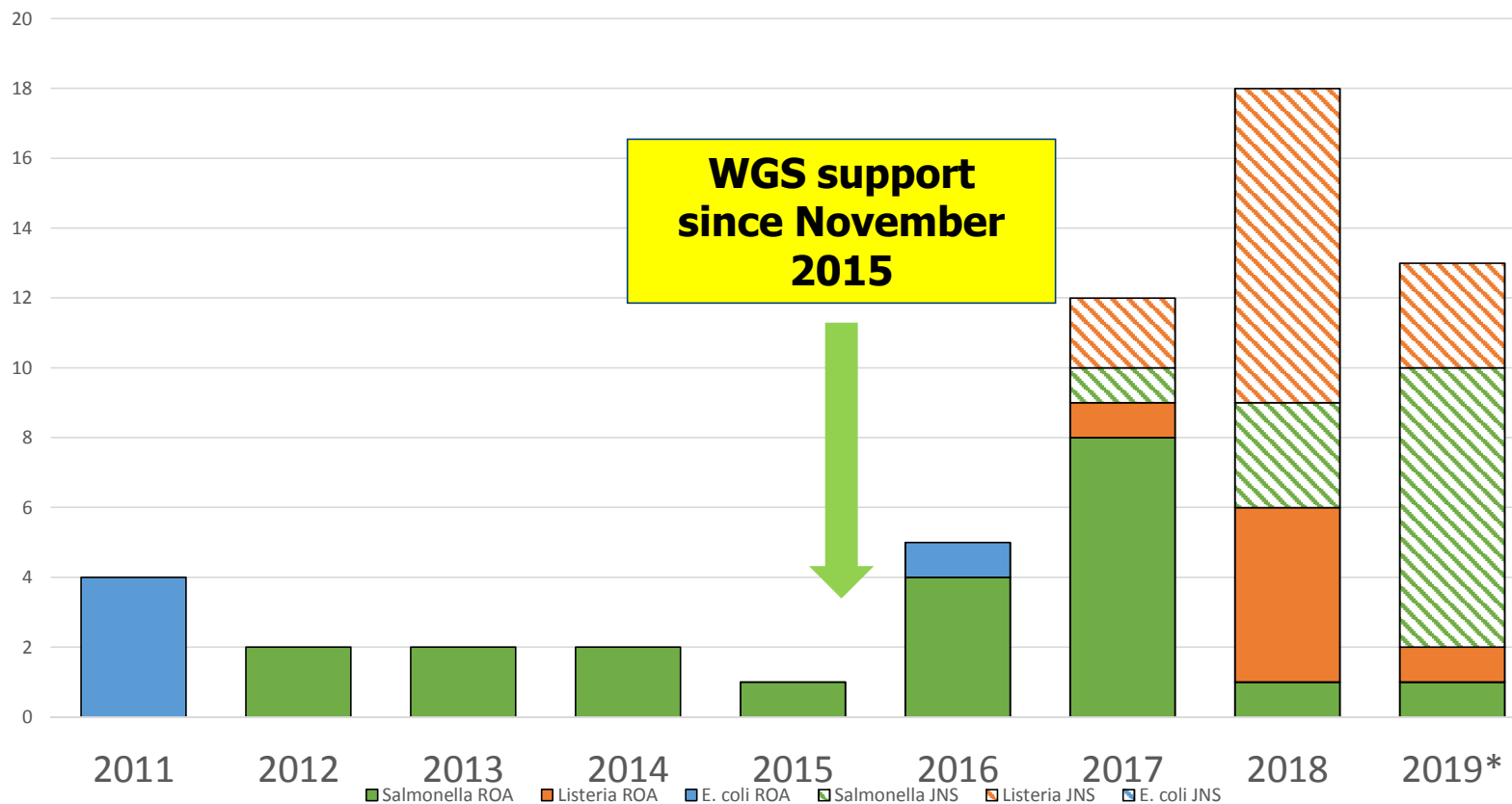


Daily Round Table meeting in ECDC

Weekly teleconference with EFSA

# ECDC-EFSA multi-country outbreak assessments and notifications for foodborne diseases, 2011 – 2019

ECDC-EFSA FWD multi-country Rapid Outbreak Assessments (ROA) and Joint Notification Summaries (JNS), 2011-2019



\*As of October 2019



**RAPID RISK ASSESSMENT**

**Multi-country outbreak of *Listeria monocytogenes* PCR serogroup IVb, MLST ST6**

6 December 2017



**JOINT ECDC–EFSA RAPID OUTBREAK ASSESSMENT**

**Multi-country outbreak of *Listeria monocytogenes* serogroup IVb, multi-locus sequence type 6, infections probably linked to frozen corn**

22 March 2018

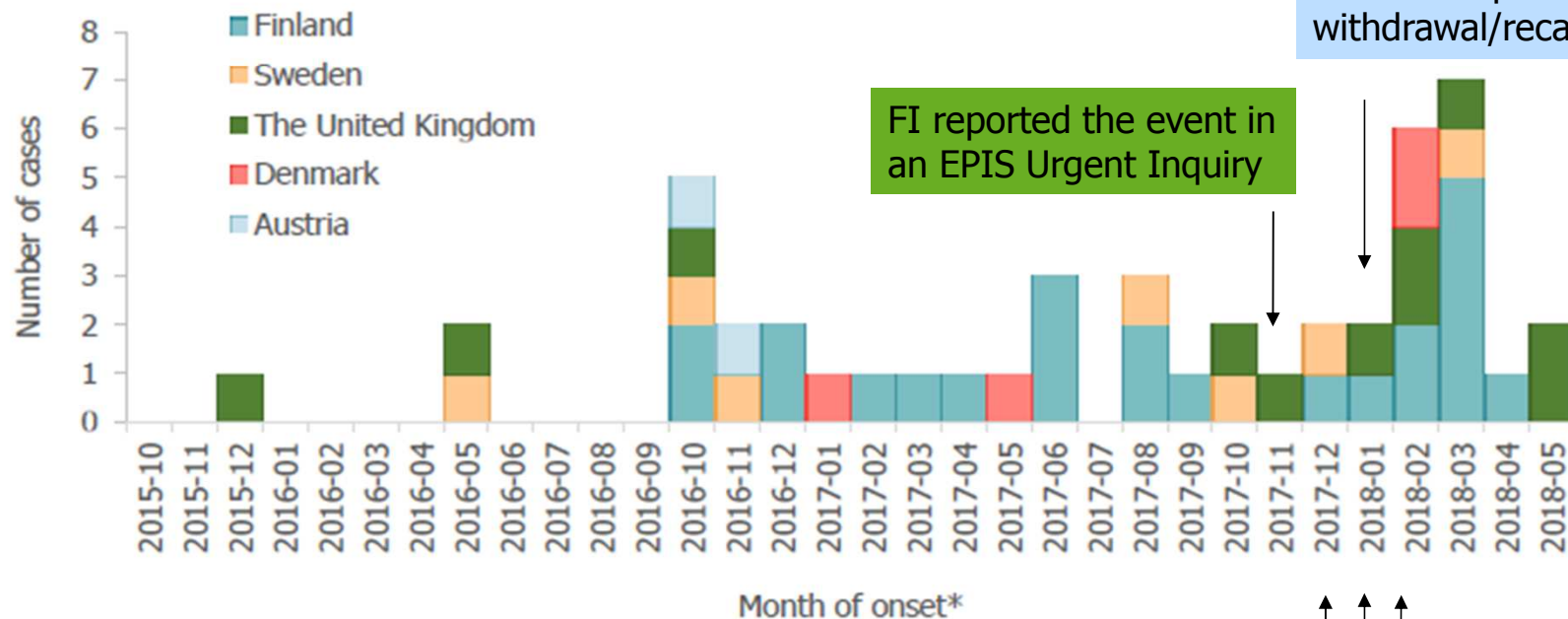


**JOINT ECDC–EFSA RAPID OUTBREAK ASSESSMENT**

**Multi-country outbreak of *Listeria monocytogenes* serogroup IVb, multi-locus sequence type 6, infections linked to frozen corn and possibly to other frozen vegetables – first update**

3 July 2018

## *Listeria monocytogenes* IVb, ST 6 confirmed outbreak cases by month of symptom onset\*, EU 2015–2018 (N=47)



RASFF alert FI, other countries followed reporting withdrawal/recall

FI reported the event in an EPIS Urgent Inquiry

\* If month of onset missing: month of sampling or month of receipt at reference laboratory

Following the request of EFSA and EC, the EURL consulted the NRLs to identify possible food matches

Some countries reported food matches related to frozen vegetable mix and frozen corn

Interviews of patients confirmed exposure to frozen corn.

Massive recall

## Greenyard takes recall initiative for frozen vegetables from Hungary

Sint-Katelijne-Waver, Belgium, 4 July 2018 – Greenyard (Euronext Brussels: GREEN) takes recall initiative for frozen vegetables from Hungary due to potential listeria contamination

In line with a decision passed by the Hungarian Food Safety Agency dated 29 June 2018, based plant, produced between 13 August

## Supermarkets recall frozen vegetables over listeria fears

6 July 2018





The recall includes bags of frozen sweetcorn and frozen mixed vegetables

Supermarkets have recalled bags of frozen vegetables over fears they could contain a deadly bacteria.

The 43 sweetcorn-based products have been withdrawn by major supermarket supplier Greenyard Frozen UK.



## Recall costs Greenyard 30 million

The recall of frozen veg by Greenyard is estimated to be costing 30 million euro. Greenyard is recalling its products; they might be infected with listeria.

## Greenyard stock plummets 30 % at market opening

Monday, 16 July 2018, 16:23



The share price of Greenyard, the Belgian vegetable supplier, fell by as much as 30 percent when the stock market opened today.



BY CARL COLLEEN

Thursday 13th September 2018, 14:23 London



## Greenyard finds Listeria 'root cause'

Following an extensive review of its Hungarian facility, Greenyard says it is ready to restart production

Global fruit and vegetable giant Greenyard has announced that it has found the root cause of the Listeria outbreak that hit the headlines earlier in the year, while also revealing that it was ready to restart production at the affected facility in Baja, Hungary.

In July, Greenyard reported on the recall of frozen products that were produced by its Hungarian production facility in Baja between 13 August 2016 and 20 June 2018, and on the ongoing investigations into an outbreak of Listeria monocytogenes between 2015 and 2018.



# Upgrade of the ECDC molecular typing platform



LISTISO 2013-09.LIST.01.CC8.Ascl.0026.Apal.0142 SEARCH IN ALL COLUMNS 16 of 16

Nodes & Labels: BN\_Cluster, LIPI-3, LIPI-4

Label by ID  
Colour by PB\_ReportingC...

- FI
- NL
- NO
- SE

BN\_Cluster

- 2013-09.LIST.01.CC8.Ascl.0026.Apal
- LIPI-3
- LIPI-4

- N
- N

0.50

- Automated upload, analysis, and outputs
- Interactive data mining opportunities
- First version ready Q1 2020

ID	PB_ReportingCountry	PB_RecordId	PB_DateUsedForStatistics	BN_REF_MLSTCLONALCOMPLI	BN_Cluster	Columns	Comfortable
2505BC17-2229-415D-831B-3...	FI	94674	2010-01-01	CC8	2013-09.LIST.01.CC8.Ascl.002...	OPEN	
30A3CF0E-037A-40A1-8E56-1...	FI	105539	2013-05-17	CC8	2013-09.LIST.01.CC8.Ascl.002...	OPEN	
33DB0695-2CE3-4740-9E0C-8...	FI	91376	2009-01-02	CC8	2013-09.LIST.01.CC8.Ascl.002...	OPEN	
4FDC3903-63F0-43EB-8B6E-2...	FI	95084	2010-02-12	CC8	2013-09.LIST.01.CC8.Ascl.002...	OPEN	
57F80319-35F8-4C0E-BDEE-E...	NO	14EP002274	2014-10-10	CC8	2013-09.LIST.01.CC8.Ascl.002...	OPEN	

# User defined sharing principles



Molecular  
Typing

Prototype version 0.17  
Powered by [MicroReact](#)

Listeria monocytogenes

Neisseria meningitidis

Visualisation

Molecular clusters/datasets

My data

Settings

Choose which data to share with other users by default:

- Assembly
- Allele identifiers

In addition to these data, epidemiological and descriptive data submitted to TESSy (except your national isolate identifier), and WGS-derived data

Save settings



# My data



Prototype version 0.17  
Powered by [MicroReact](#)

Listeria monocytogenes    Neisseria meningitidis

Visualisation    Molecular clusters/datasets    **My data**    Settings

This table shows your uploaded data, you can choose to share or not share individual isolates with other users.

Save settings

Column visibility    Copy    CSV    Show  entries

Listeria monocytogenes isolates

Country	BatchId	RecordId, link to 7 AD matches	ECDC Id	Created date	Modified date	QC (PASS/FAIL)	QC (Contamination)	QC (Core loci detected)
<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>
DE		<a href="#">LM18-04708</a>	testUI607_2	2019-10-24 16:29:48	2019-10-25 09:29:46	Accepted	PASS	1747
DE		<a href="#">181109-18-7861-LM18-04254</a>	testUI607_1	2019-10-24 16:29:48	2019-10-25 09:29:42	Accepted	PASS	1747

# Clusters



Prototype version 0.17  
Powered by [MicroReact](#)

Listeria monocytogenes    Neisseria meningitidis

Visualisation    Molecular clusters/datasets    My data    Settings

These tables shows molecular clusters detected by ECDC by applying automated algorithms, see respective surveillance protocols for details. Only multi-country clusters and clusters in your country are shown. Included are also generated datasets of particular interest.

Column visibility    Copy    CSV    Show  entries

Search:

### Listeria clusters

Cluster ID	Cluster info	Event ID	Cluster status	Number of isolates	Countries	Updated (7 d)	First date	Last date	Last updated	Extended cluster	Genetic background
<input type="text" value="Search Clu:"/>	<input type="text" value="Search Clu:"/>	<input type="text" value="Search Eve"/>	<input type="text" value="Search Clu:"/>	<input type="text" value="Search Nur"/>	<input type="text" value="Search Cou"/>	<input type="text" value="Search Upc"/>	<input type="text" value="Search Firs"/>	<input type="text" value="Search Las"/>	<input type="text" value="Search Las"/>	<input type="text" value="Search Extu"/>	<input type="text" value="Search Ger"/>
<a href="#">2014-03.LIST.01.CC6.AscI.000</a> <a href="#">2.ApaI.0064</a>		<a href="#">UI509 - cluster 2</a>	OPEN	37	ES(13), BE(1), NL(8), UK(4), IE(1), DK(1), DE(8), FR(1)	ES(13), BE(1), NL(8), UK(4), IE(1), DK(1), DE(8), FR(1)	2009-12-30	2018-08-26	2019-11-04	<a href="#">2014-03.LIST.01.CC6.AscI.000</a> <a href="#">2.ApaI.0064 +7 AD</a>	<a href="#">2014-03.LIST.01.CC6.AscI.000</a> <a href="#">2.ApaI.0064 +5 0AD</a>
<a href="#">2014-05.LIST.09.CC6.AscI.000</a> <a href="#">2.ApaI.0393</a>			OPEN	2	FI(2)	FI(2)	2010-09-05	2011-06-23	2019-11-04	<a href="#">2014-05.LIST.09.CC6.AscI.000</a> <a href="#">2.ApaI.0393 +7 AD</a>	<a href="#">2014-05.LIST.09.CC6.AscI.000</a> <a href="#">2.ApaI.0393 +5 0AD</a>
<a href="#">2015-04.LIST.04.CC6.AscI.000</a> <a href="#">2.ApaI.0072</a>		<a href="#">UI583_test</a>	OPEN	43	NL(31), BE(3), DE(1), (5), FR(0), DK(2)	NL(31), BE(3), DE(1), FR(0), DK(2)	2003-04-09	2015-03-26	2019-11-04	<a href="#">2015-04.LIST.04.CC6.AscI.000</a> <a href="#">2.ApaI.0072 +7 AD</a>	<a href="#">2015-04.LIST.04.CC6.AscI.000</a> <a href="#">2.ApaI.0072 +5 0AD</a>
<a href="#">2016-11.LIST.01</a>		<a href="#">UI452</a>	OPEN	25	DK(9), SE(4), EE(9), FI(2), FR(1)		2014-07-23	2019-02-18	2019-10-23	<a href="#">2016-11.LIST.01 +7AD</a>	<a href="#">2016-11.LIST.01 +50AD</a>

# Visualisation

Pathogen:  
Listeria

Clustering method:  
Single linkage

Include data from SRA and ENA  
 Include data from all countries

From countries:

Sampled within X days:

Uploaded within X days:

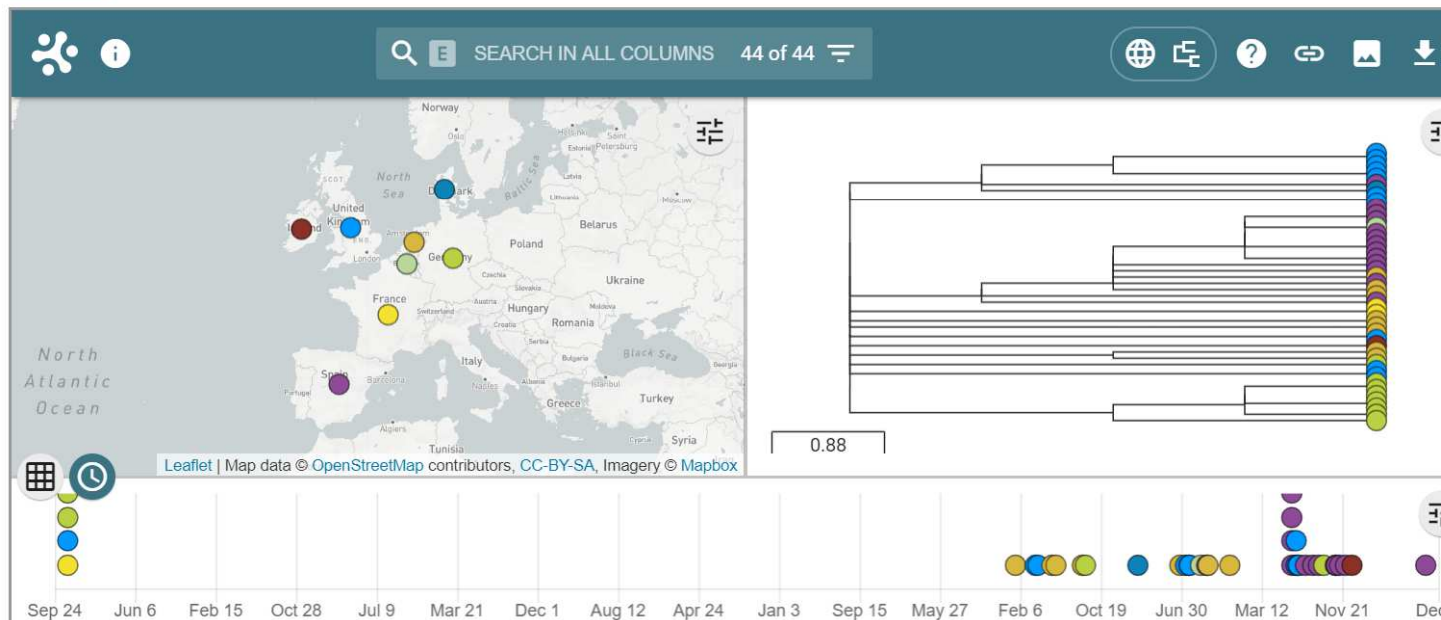
Search for specific cluster/dataset:

Search for specific UI:

Search for specific RecordIds:

After filtering, also include all matches within X genetic differences:

URL for sharing:  
<http://microreact.ecdcnet.>  
URL for recreating:  
<http://zbiodev1.idmdevdm>

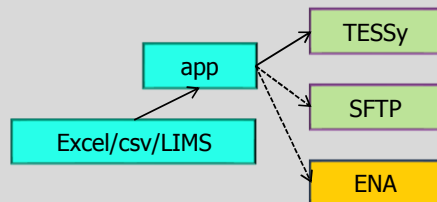


# Options for WGS data upload

## ECDC WGS upload application

### Features

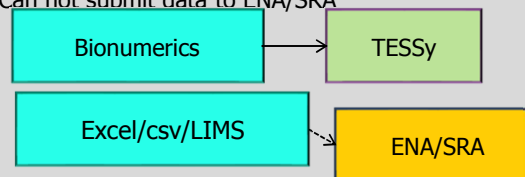
- Can be configured to import data from databases or local files (MySQL, SQL Server, SQLite, Excel, csv)
- Configure only once, single click upload
- Can upload assemblies to TESSy and SFTP, raw reads to SFTP and ENA (configurable)
- Data sharing through SFTP and ENA



## ECDC Bionumerics client plugin

### Features

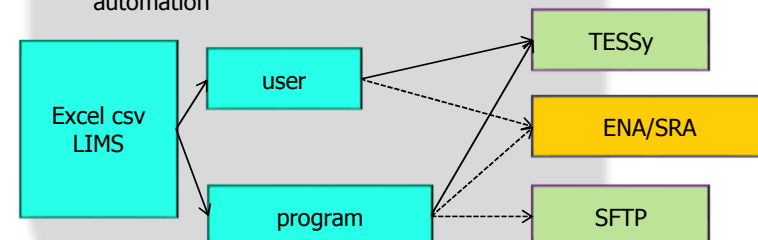
- Requires Bionumerics and that either ENA/SRA run accession or assemblies are stored in the Bionumerics database
- Simple upload process
- Can upload assemblies and ENA/SRA identifiers to TESSy
- Can not share raw reads through SFTP
- Can not submit data to ENA/SRA



## Direct TESSy submission – manual or machine-to-machine

### Features

- Can upload assemblies and ENA/SRA identifiers to TESSy
- Manual upload is easy to set up but involves recurring manual work
- Machine-to-machine upload requires development but enables high levels of automation



# Data sharing principles

- WGS data and minimal epidemiological data are shared with ECDC, either privately using SFTP or publically using ENA/SRA.
- Full epidemiological data together with a representative genome are shared between affected member states through the EPIS platform during outbreak investigations.
- Sequence data and epidemiological data are privately shared between ECDC, EFSA and EURLs for outbreaks that involve food or animal sources.
- The main ECDC outputs from outbreak investigations are Rapid Risk Assessments (public) and Joint Notification Summaries to the European Commission (non-public).
- ECDC encourages and can assist with release of at least one raw reads genome to be released in the public domain when a Rapid Risk Assessment is released.

# ECDC WGS Strategic Framework: Acknowledgements



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