



Public Health
England

Protecting and improving the nation's health

International *Salmonella* Outbreaks – Pinkies & Polish Eggs

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1. Introduction

- *Salmonella* in England
- WGS and assessing genetic similarity between *Salmonella* genomes

2. *Salmonella* outbreak investigations – 2 examples

3. Implications for public health and food safety with use of WGS

4. Summary & conclusions

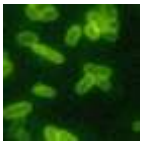


Introduction

Listeria
≈170/year



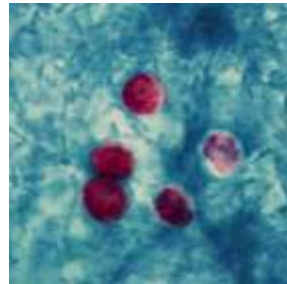
STEC
≈800/year



Shigella
≈2,500/year



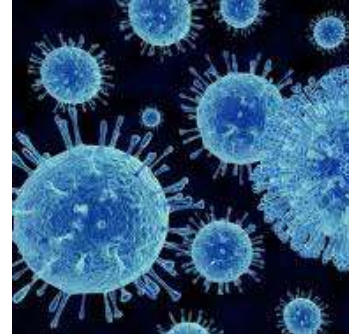
Enteric protozoa
(*Cryptosporidium* /
Giardia)
≈8,000/year



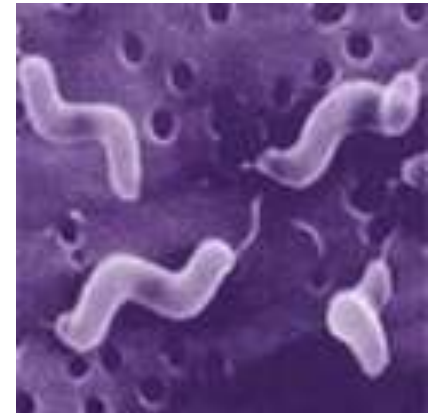
Salmonella
≈8,000/year



Enteric viruses
(norovirus /
rotavirus)
≈10,000/year

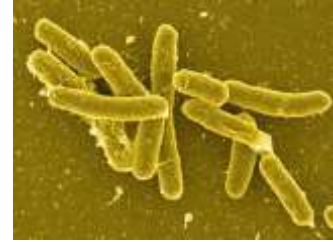


Campylobacter
≈50,000/year





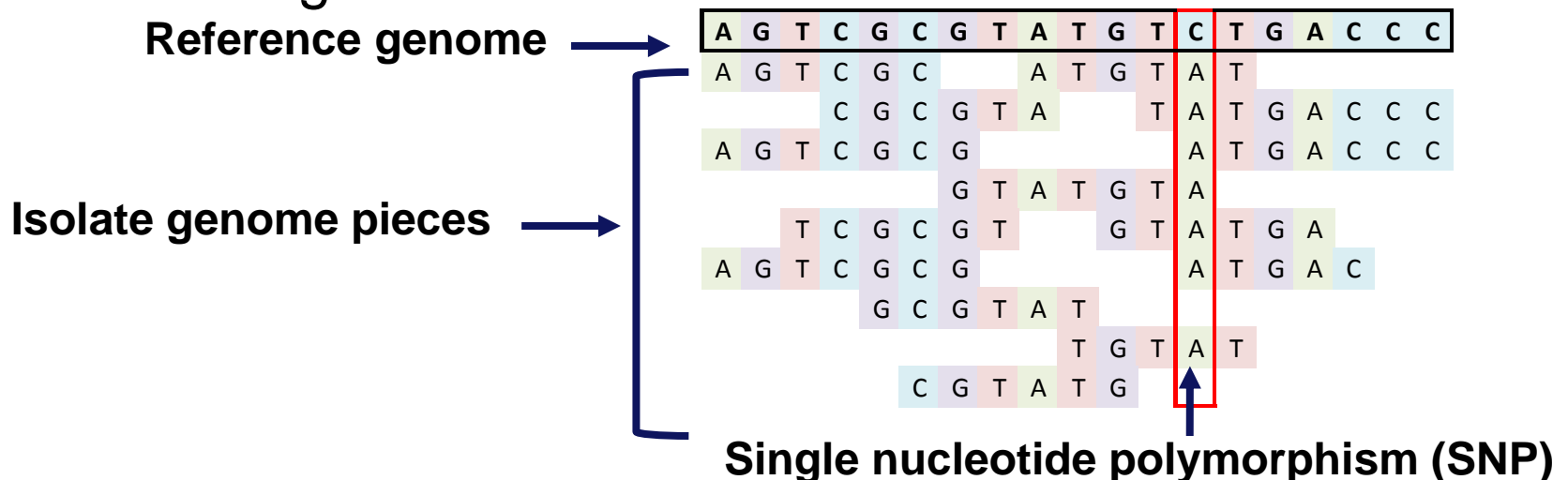
Introduction - *Salmonella*



- Symptoms commonly include: diarrhoea, stomach cramps, nausea, vomiting and fever
- Disease onset usually 12 - 72 hours after exposure and illness usually lasts from 4 to 7 days.
- Over 2600 serovars of *Salmonella* bacteria
- *Salmonella* is present in the intestines of a wide range of animal species
- *Salmonella* Enteritidis most commonly reported serovar in the UK = ~30% of all reports in 2017. Often associated with poultry products

Introduction - whole genome sequencing

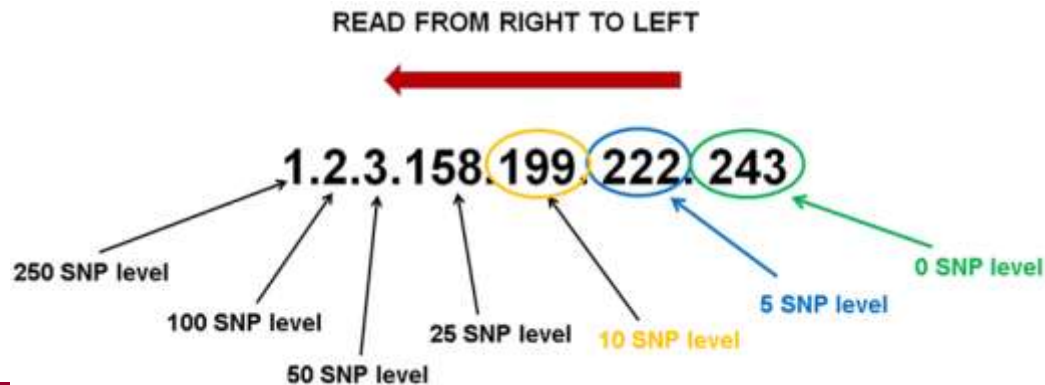
- WGS is a process that takes the bacteria's DNA and breaks it into small fragments that are easy to read
- These sections are then lined up against a reference genome and any differences are noted
- A **SNP** or **single nucleotide polymorphism** is a one base difference in the bacteria's DNA compared to a reference genome





Whole genome sequencing at PHE

- Routine WGS implemented for *Salmonella* from April 2014 and we sequence ~10,000 isolates a year.
- Stopped phage typing in November 2015
- ‘SNP address’ indicates how closely related genetically an isolate is to other isolates in the database
- 5 SNPs or less → cases likely to be epidemiologically linked / share a common exposure





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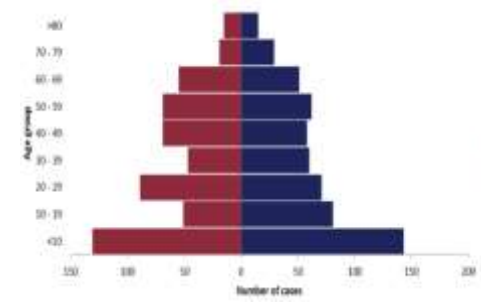
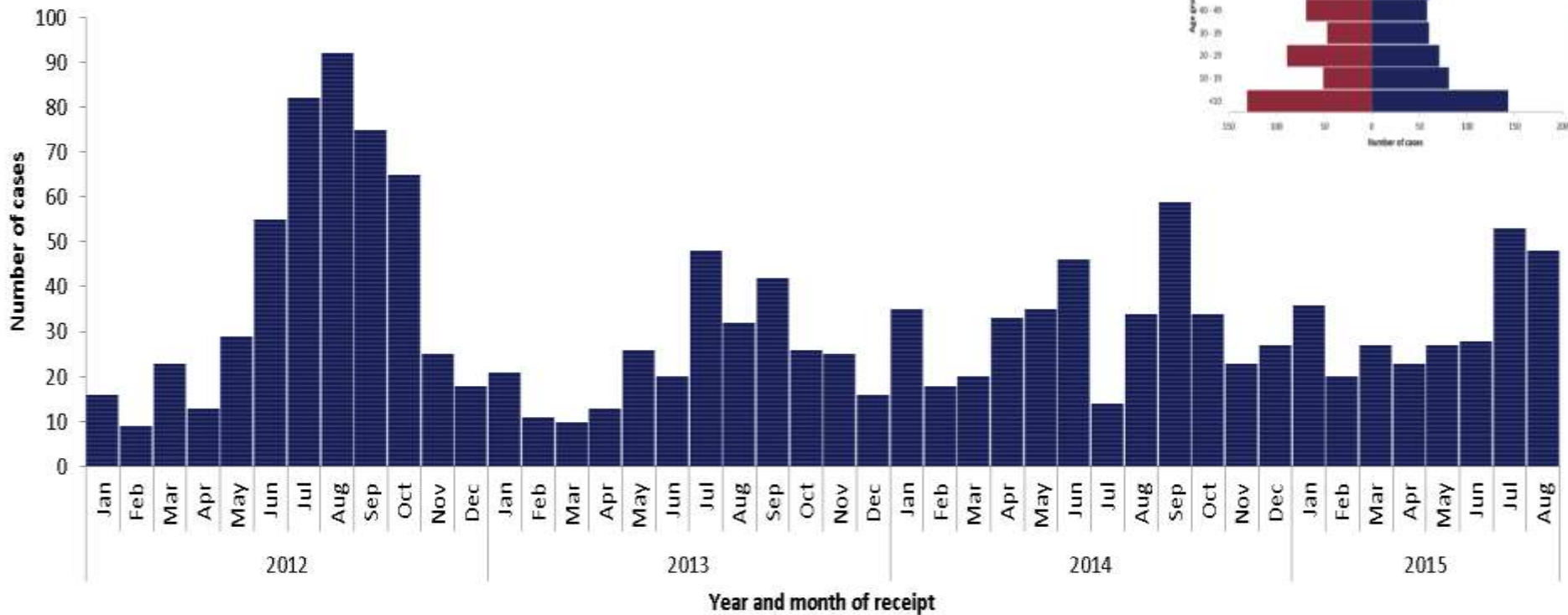
Salmonella Enteritidis PT8 t5:280 outbreak 2015 - 2018

Acknowledgements: Sanch Kanagarajah and Matt Edmunds



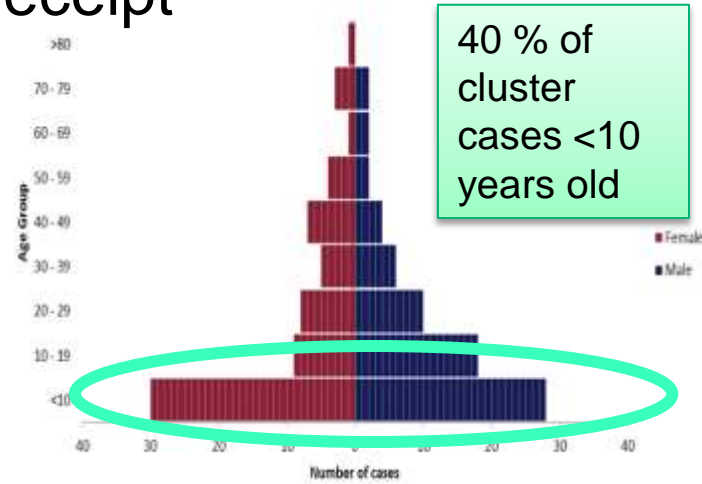
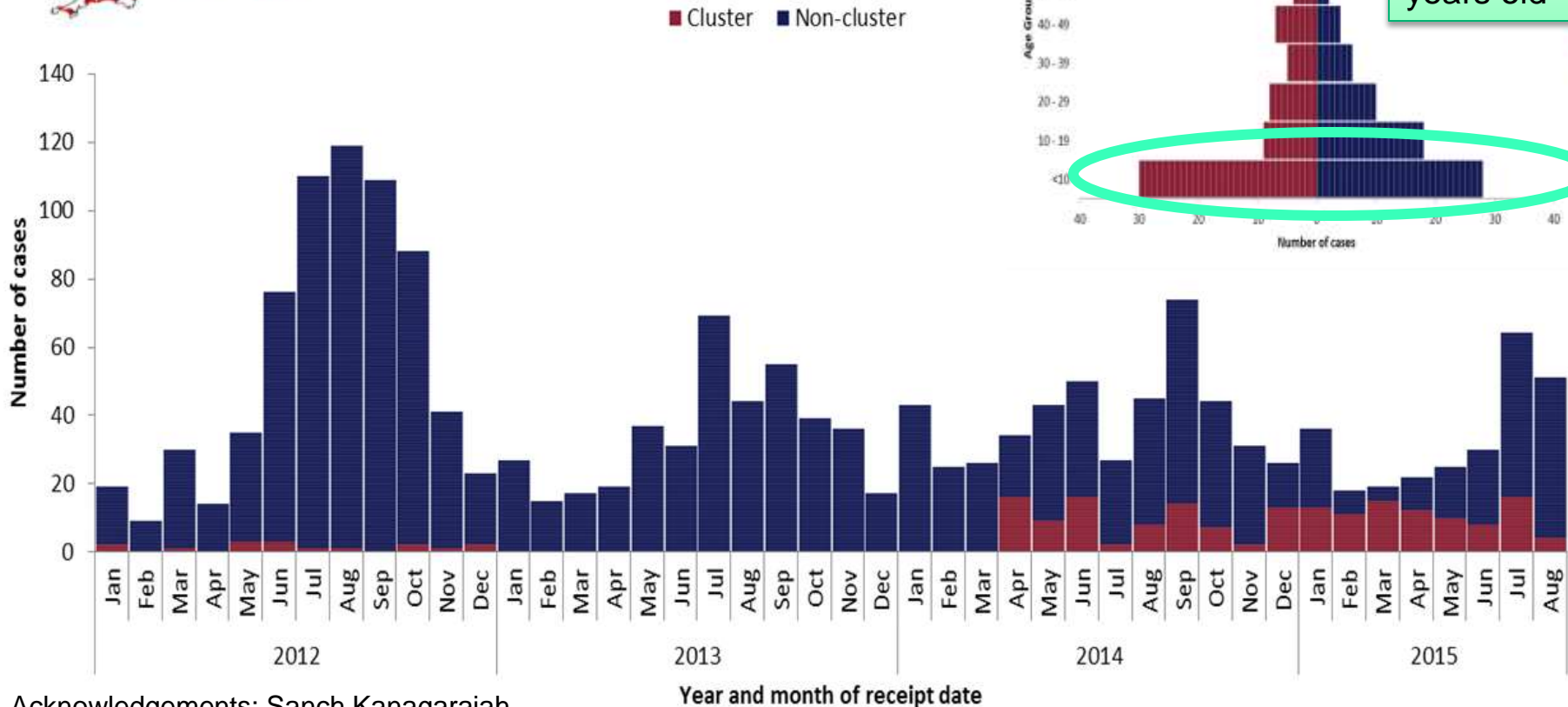
Salmonella Enteritidis PT8

Distribution of S. Enteritidis PT8 cases by month of sample receipt, England, 2012 to 2015



But with WGS...

Distribution of *S. Enteritidis* 1.5.159.280.280.280% cases by month of sample receipt



Acknowledgements: Sanch Kanagarajah



Outbreak investigation – 2015/2016

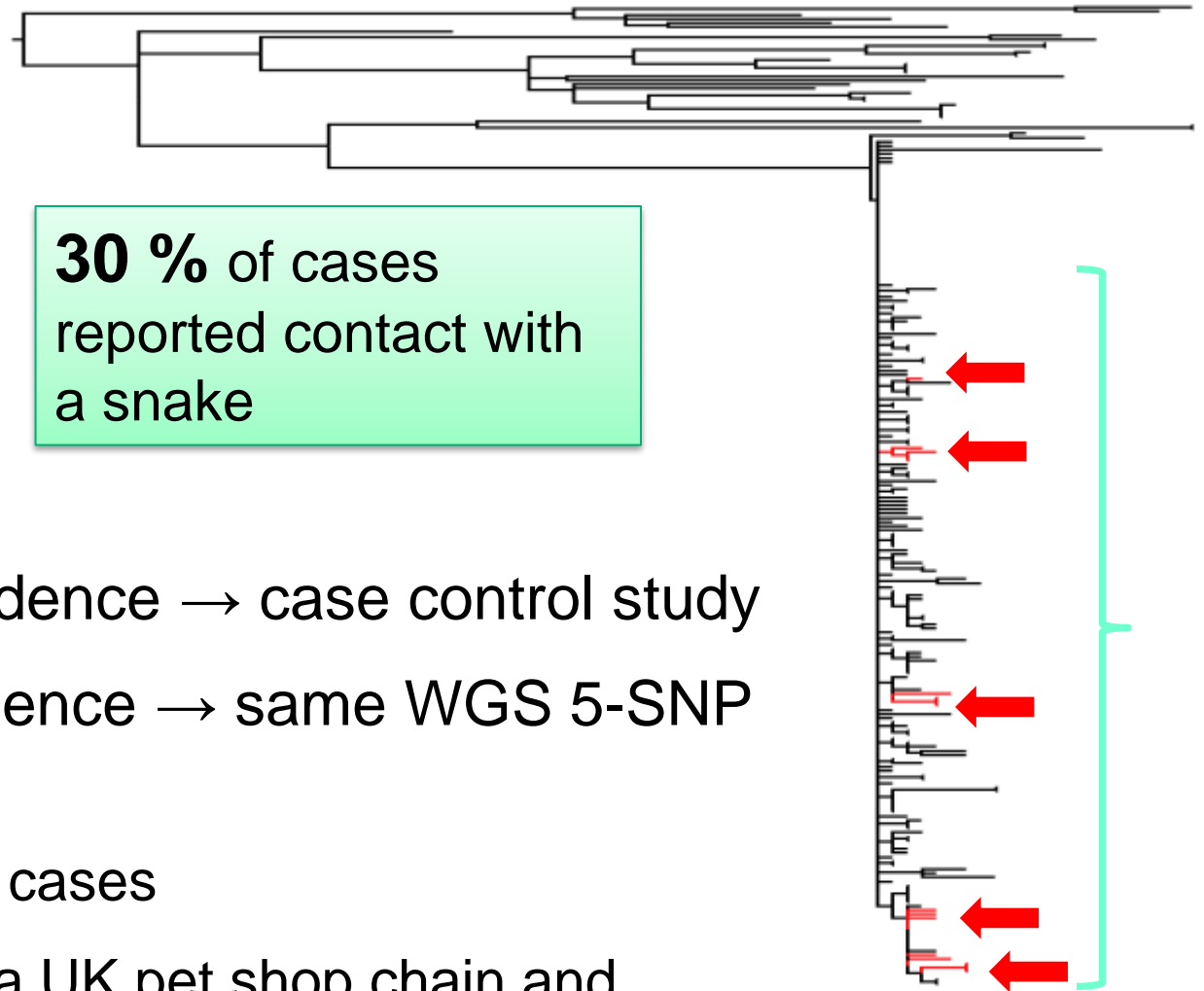


30 % of cases
reported contact with
a snake

Epidemiological evidence → case control study

Microbiological evidence → same WGS 5-SNP
address in:

- ✓ Outbreak (human) cases
- ✓ Feeder mice from a UK pet shop chain and source farm in another European country



Phylogenetic tree

Red: feeder mice
Black: human cases



EU investigation

- Communications with other countries → confirmed /probable cases reported in 3 other EU countries.
- 278 confirmed cases reported by November 2016 (275 in UK)
- Control measures implemented on farm ~April 2016:
 - Acidification of drinking water
 - UV treatment of mice
- Advice leaflets produced



Multi-country outbreak of Salmonella Enteritidis PT8 infection, MLVA type 2-10-8-5-2, associated with handling of feeder mice – 1 December 2016. Stockholm: ECDC; 2016.



But in 2017 and 2018...

- Cases continued to be reported in 2017 and 2018 at rate of ~1-2 per week
- Since January 2017 there have been 151 cases reported
- Occasional questionnaires mentioned snake ownership
- What now?
 - Interventions at farm not effective → ongoing contamination at same source?
 - New source of contamination?
 - Persistently infected pet reptiles?





Outbreak investigation 2017/2018

1. Epidemiology:

➤ Descriptive epidemiology:

- no change in incidence rate pre and post interventions
- no statistically significant change in case median age, gender or geographical distribution compared to 2015/2016 cases

➤ Case interviews ongoing – high proportion of cases report having a pet snake

2. Microbiology:

- Feeder mice sampled and tested for *Salmonella* (from multiple producers)



Challenges

1. Protracted investigation with only 'drip-drip' reporting of cases
2. Reptiles are not classified as 'pets' → legal loophole
3. Welfare and practicality issues if break the supply chain.
4. Source of infection in another country & control difficult!
5. Snakes can persistently shed *Salmonella*...



Next steps...

1. Continuing to interview cases → risk factors
2. Sampling pinkies and fuzzies from UK distributors
3. Discussing options for controls at production
4. Considering legal powers for control – Animal Byproducts legislation or Animal Feed legislation
5. Provision of targeted pet reptile owner advice on handling of pet reptiles and their feed
6. Notification of problem to industry



Conclusions

- Wouldn't have detected this outbreak without WGS!
- Quickly able to establish hypothesis based on outbreak epidemiology & phylogeny
- Shouldn't ignore 'drip drip' outbreaks – 1 or 2 cases per week amounts to large burden over time
- Less leverage when only UK affected
- If don't control at source usually impossible to fully control the outbreak
- Weak legal basis for control



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Multi-country outbreak of *Salmonella* Enteritidis PT8 t5:175/360

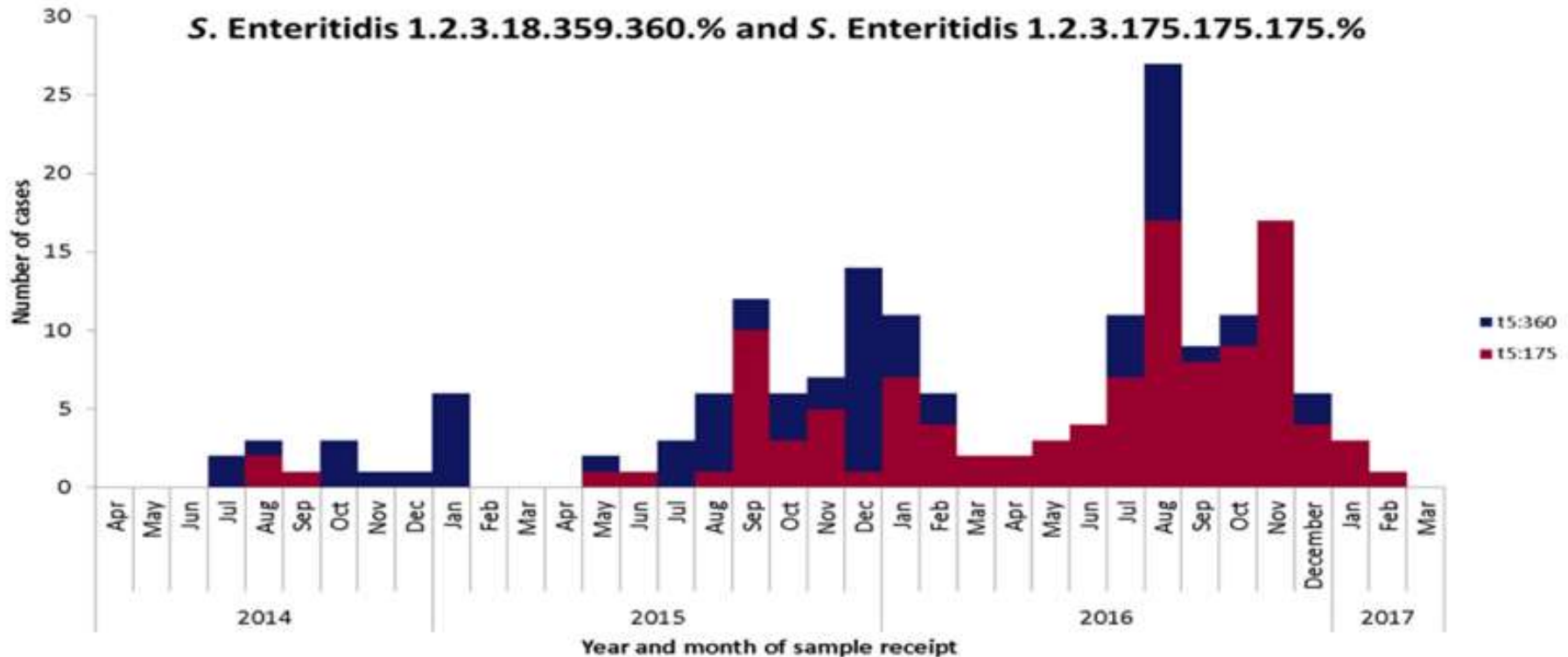
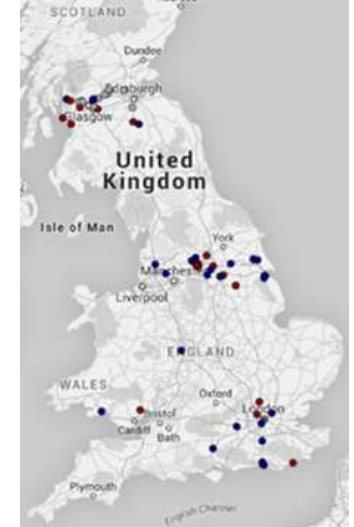


National investigations 2015/2016

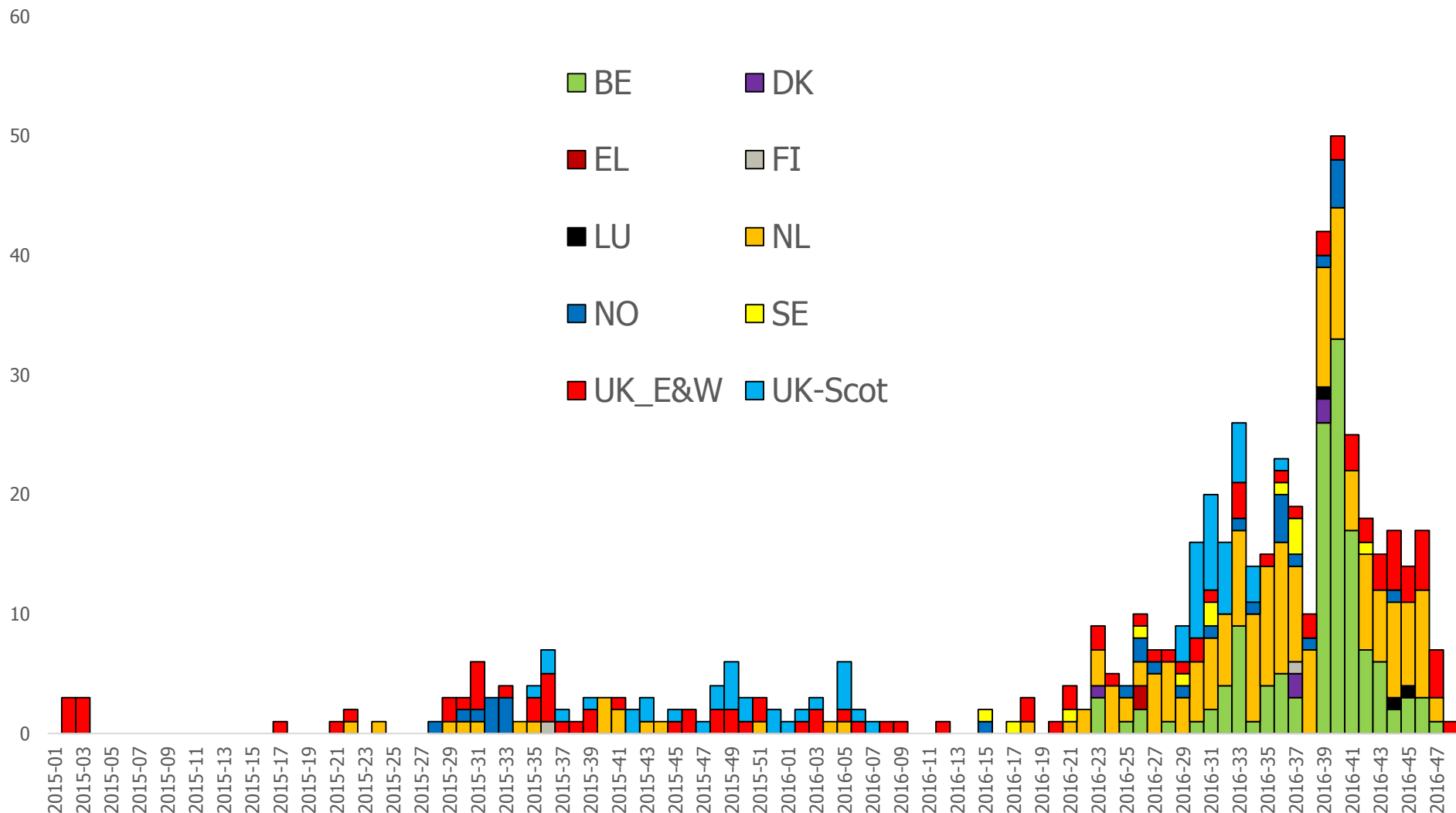
- December 2015: cluster of 17 *Salmonella* Enteritidis MLVA 2-9-7-3-2 cases first detected by Scotland
- January 2016: confirmed same strains present in England and Wales = 57 cases since mid 2104
- Food chain investigations lead to identification of an egg distributor in the EU but no further – then case reports stopped
- Re-emerged in August 2016 → HPS and PHE notified the EU community



Distribution of *S. Enteritidis* 1.2.3.18.359.360.%
and 1.2.3.18.175.175.% cases by month of
sample receipt (n = 185)



S. Enteritidis 2-9-7-3-2: cases by country, week of statistics and case classification (n=533), EU/EEA 2015-2016, as of 12/12/2016



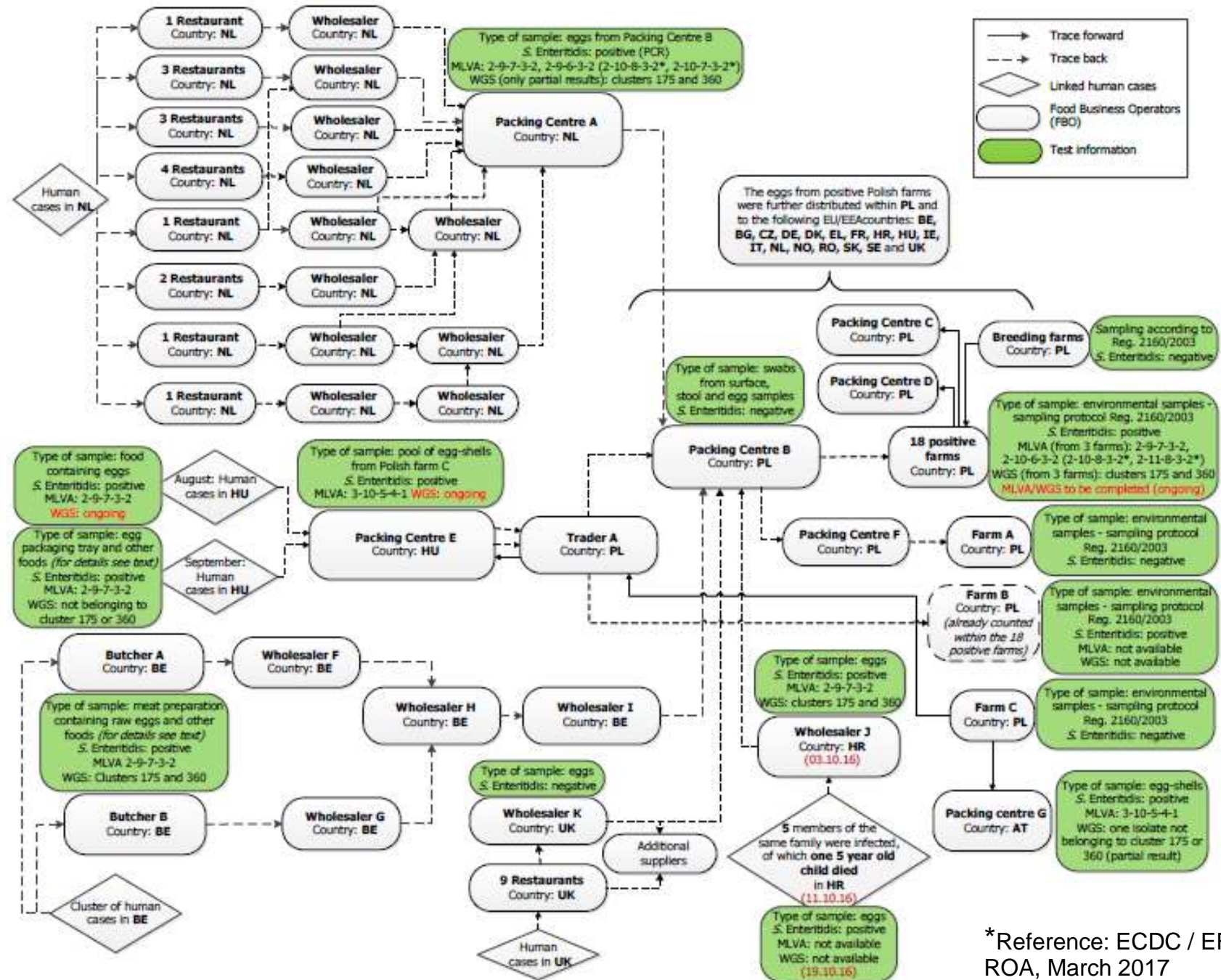
*Reference: European Centre for Disease Prevention and Control and European Food Safety Authority. Multi-country outbreak of *Salmonella* Enteritidis phage type 8, MLVA type 2-9-7-3-2 and 2-9-6-3-2 infections, 7 March 2017.



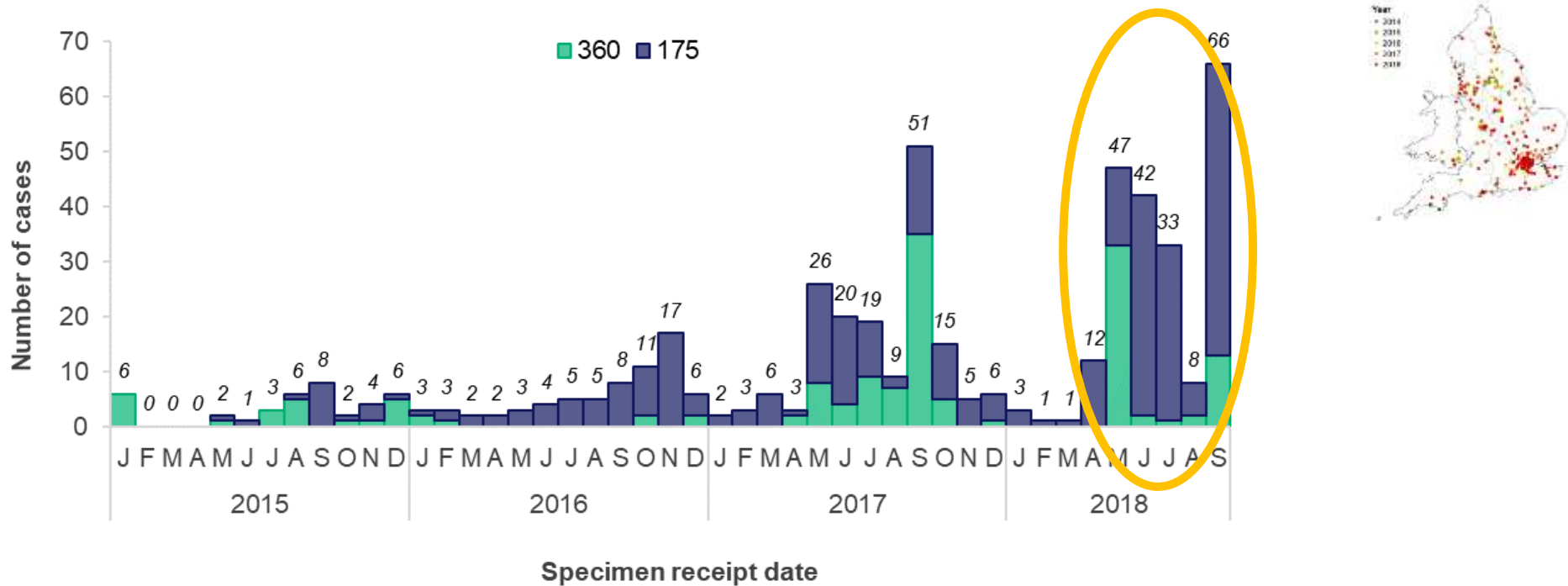
EU investigations 2016

- Cases reported from 13 other EU countries & UK.
- In total 533 confirmed/probable cases reported in EU/EEA countries up to December 2016
- NL case control study → links made to same egg distributor as made in UK investigation
- NL sampled >5000 eggs → matching outbreak strains detected in eggs from Poland
- Regulation (EC) No. 2160/2003: 82 flocks on 18 farms in Poland +ve for Enteritidis and controls applied from Oct 2016.
- Last date of distribution of contaminated eggs= 12 Dec 2016

Figure 5. Graphical representation of traceability and testing information available in RASFF or provided by Member States to EFSA, as of 1 March 2017



*Reference: ECDC / EFSA ROA, March 2017



Re-emergence of cases in the UK in March 2017

Now what?

- Different source/ food vehicle?
- Still circulating outbreak strain in table eggs &/or egg products?



Challenges

In egg associated outbreak investigations:

1. Eggs and egg products = common exposures. UK consumption ave = ~53% (NDNS).
2. Complex supply chain and poor traceability
3. Cross contamination in the home and at catering premises can complicate investigation
4. Egg shelf life = 28 days from lay and consumer surveys indicate only ~4% consumers keep longer than 30 days.
5. Very short turn around time at catering premises



Challenges – the chicken reservoir

6. Laying hens have a long production period. Risk (possibly increasing) of persistent contamination between flocks
7. Most *Salmonella* infection in poultry is sub-clinical
8. Vaccination alone not the answer!
9. Intermittent shedding and % contaminated eggs from infected flocks low – needle in haystack.





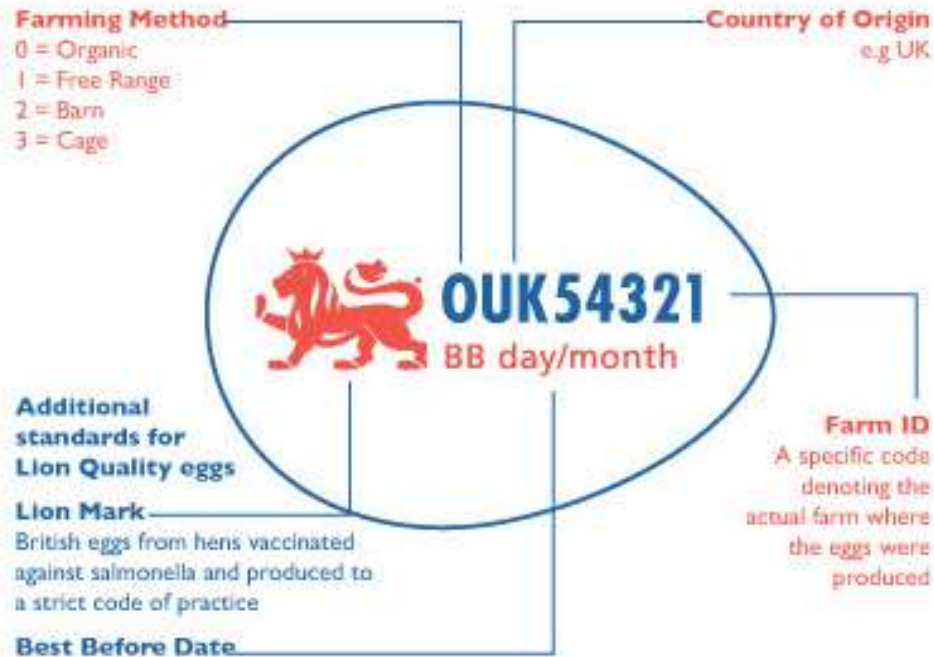
But we have strong legal powers...

Regulation (EC) No 2160/2003 → EU *Salmonella* controls

1. Chickens must be routinely monitored for *Salmonella* in *Salmonella* National Control Programmes (Reg. (EC) No 517/2011)
2. Producer can only market Class A eggs if flock *Salmonella* Enteritidis/Typhimurium negative
3. Where evidence of a link with a foodborne outbreak → suspect flock(s) should be inspected and sampling carried out to confirm *Salmonella* status
4. If flock positive → eggs diverted to heat treatment/ flock taken out of production permanently



Producer codes



Source: <https://www.egginfo.co.uk/egg-facts-and-figures/industry-information/egg-codes-and-quality>



Conclusions

- Egg associated S. Enteritidis outbreaks → need to identify source and control at source for long term resolution.
- WGS enabled detection of re-emergence of the same outbreak strains → previous controls not fully effective
- Many challenges to effectively investigating egg associated outbreaks – traceability limitations!
- If can identify suspect/implicated producers/ packing centres → strong legal basis for controls



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Final Thoughts





WGS & implications for public health

- Use of WGS provides improved resolution for *Salmonella* strain discrimination:
 - easier to detect outbreaks and (mostly) identify source
 - we now know when controls have not been fully effective
 - if we don't find and control the source the outbreak goes on!
- Enhanced outbreak detection → significant resource implications for everyone
- Product traceability and effective food chain analysis now more important than ever to identify the source to implement effective controls



In conclusion...

1. Two international outbreaks of *S. Enteritidis* – both with a non - UK source
 - Feeder mice outbreak difficult to control due to lack of legal powers/ basis
 - PL eggs outbreak should be easy to control as strong legal basis but food chain investigations very difficult
2. We need to get ‘smarter’ in how we manage investigations
3. Close working between all partners involved in food safety and public health now more important than ever



Acknowledgements

- Jacquelyn McCormick
- Sanch Kanagarajah
- Tim Dallman
- Hassan Hartman
- Elizabeth De Pinna
- Marie Chattaway
- Lara Utsi
- Gareth Hughes
- Matt Edmunds
- Deb Morgan
- Tina Potter

Others

- PHE Field Services
- Outbreak Control Teams
- Food Standards Agency
- Local Authorities
- Animal and Plant Health Agency
- ECDC and EFSA
- EU Member States and EEA countries



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**Thank you for
listening**

