The Danish experience in *Salmonella* Enteritidis control - in layers

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SE is the most commonly occurring salmonella in human disease globally

WHO Estim. > 100 million cases of human disease each year

Galanis E., et al. EID 2006
Salmonella can be effectively controlled
Prevalence of *Salmonella* infected Danish broiler flocks
Incidence of human salmonellosis attributable to broilers in Denmark
Linking diseases and food/animal reservoirs

Principle of the Danish Salmonella Source Attribution model

Compare the number of (reported) human cases caused by different *Salmonella* subtypes with the distribution of *Salmonella* subtypes isolated from the various food (-animal) sources.
Salmonella prevalence in fresh pork – introduction of serology
Pork associated human salmonellosis in Denmark

![Chart showing cases per 100,000 inhabitants from 1988 to 2009, with a significant decrease after an intervention in 1993.]
Egg associated human salmonellosis in Denmark, 1988-1997
The table egg production pyramide - When a good thing turns bad
Layer industry structure

- Genetic Improvement
- Pedigree Selection

1. DIARRHEA
   - Hundreds of thousands of cases

2. GGP
   - Tens of thousands
   - 1,000,000

3. PARENT STOCK
   - 50,000,000

4. COMMERCIAL LAYERS
   - 5,400,000,000

5. PROCESSING/RETAILERS
   - 1,000,000,000,000 eggs

6. CONSUMERS
”think globally, act locally”
– begin by eradicating SE from all pedigree!

Locally Infected pedigree
>>
A global public health problem
Danish shell-egg production system

Import of 80,000 day old parent birds to six locations

3 hatcheries
4,5 mill day old layers

Rearing
4,5 million layers

400 producers
1 billion shell eggs

5.2 Million consumers
Danish SE eradication strategy
Top Down Eradication Strategy

- Test and destroy infected imports of day old layer breeders
- Monitor and destroy infected breeding flocks
- Test and destroy infected layer flocks, alternatively decontaminate table eggs (heat treat)
- Cleaning and disinfection of infected premises
- All Danish producers involved
- All serotypes, but special emphasis on S. Typhimurium and S. Enteritidis
Table-egg control programme
- Technical task force

• Equal representation of industry and public sector

• Responsibility for technical aspects, e.g.
  – sampling plans,
  – detection techniques,
  – sanitation,
  – training,
  – improvements
<table>
<thead>
<tr>
<th>Time</th>
<th>Samples taken</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rearing flocks</strong></td>
<td></td>
<td></td>
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<tr>
<td>Day-old&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>Per delivery</td>
<td>5 transport crates from one delivery: crate liners (&gt;1m² in total) or swab samples (&gt;1m² in total). Analysed as one pool.</td>
</tr>
<tr>
<td>1st &amp; 2nd week&lt;sup&gt;h,c&lt;/sup&gt;</td>
<td>Per unit&lt;sup&gt;d&lt;/sup&gt;</td>
<td>-</td>
</tr>
<tr>
<td>4th week&lt;sup&gt;ab&lt;/sup&gt;</td>
<td></td>
<td>5 pairs of boot swaps (analysed as two pooled samples), or 1 faeces sample consisting of 2x150g.</td>
</tr>
<tr>
<td>8th week&lt;sup&gt;h,c&lt;/sup&gt;</td>
<td>Per unit</td>
<td>2 pairs of boot swabs (analysed as one pooled sample). Cage birds: 60 samples of fresh droppings (1g). Analysed as one pool.</td>
</tr>
<tr>
<td>2 weeks prior to moving&lt;sup&gt;h,c&lt;/sup&gt;</td>
<td>Per unit</td>
<td>5 pairs of boot swabs (analysed as two pooled samples), or 1 faeces sample consisting of 2x150g.</td>
</tr>
</tbody>
</table>

<sup>h</sup> 2 pairs of boot swabs (analysed as one pooled sample) or 1 faeces sample of 60g.

<sup>c</sup> 2 pairs of boot swabs (analysed as one pooled sample). Cage birds: 60 samples of fresh droppings (1g). Analysed as one pool.

<sup>ab</sup> 2 pairs of boot swabs (analysed as one pooled sample) or 1 faeces sample of 60g.
Table A31. Salmonella surveillance programme for the rearing flocks and adult flocks of the grandparent and parent generation of the broiler and table egg production, 2009

<table>
<thead>
<tr>
<th>Time</th>
<th>Samples taken</th>
<th>Material</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Adult flocks</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Every two weeks(^b)</td>
<td>Per flock</td>
<td>Hatcher basket liners from 5 baskets (&gt;1m² in total) or 10g of broken eggshells from each of 25 hatcher baskets (reduced to 25g sub-sample). Analysed as one pool.</td>
<td>Hatcher basket liners from 5 baskets (&gt;1m² in total) or 10g of broken eggshells from each of 25 hatcher baskets (reduced to 25g sub-sample). Analysed as one pool.</td>
</tr>
<tr>
<td>(Every 16th week(^d)(^f))</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>After each hatch(^b)</td>
<td>Per hatch</td>
<td>Wet dust samples. Up to four hatcher of the same flock can be pooled.</td>
<td>Wet dust samples. Up to four hatcher of the same flock can be pooled.</td>
</tr>
<tr>
<td>Every week(^b)</td>
<td>Per unit</td>
<td>-</td>
<td>2 pairs of boot swabs (analysed as one pooled sample) or 1 faeces sample of 60g.</td>
</tr>
<tr>
<td>0-4 weeks after moving, 8-0 weeks before slaughter(^c)</td>
<td>Per unit</td>
<td>5 pairs of boot swabs (analysed as two pooled samples), or 1 faeces sample consisting of 2x150g.</td>
<td>5 pairs of boot swabs (analysed as two pooled samples), or 1 faeces sample consisting of 2x150g.</td>
</tr>
<tr>
<td>After positive findings(^c)</td>
<td>Per unit</td>
<td>5 pairs of boot swabs (analysed as two pooled samples), 2 dust samples (250 ml) and 5 birds (analysed for antimicrobial substances).</td>
<td>5 pairs of boot swabs (analysed as two pooled samples), 2 dust samples (250 ml) and 5 birds (analysed for antimicrobial substances).</td>
</tr>
</tbody>
</table>

\(^a\) Sampling requirements set out by Regulation (EC) 2160/2003.
\(^b\) Samples collected by the food business operator.
\(^c\) Order no 1259 of 15/12/2008.
\(^d\) A unit (house) may harbour part of a flock or more than one flock, depending on the size of the unit.
\(^e\) Samples collected by the Regional Veterinary and Food Control Authorities.
\(^f\) When eggs from a flock exceed the capacity of one incubator, each incubator should be sampled as described.

Source: Danish Veterinary and Food Administration
A Danish speciality - “boot swabs”

A highly sensitive sampling method for bacteriological detection of salmonella in poultry houses

Table A.33. Salmonella surveillance programme for the pullet-rearing, table egg layer and barnyard/hobby flocks in the table egg production, 2009

<table>
<thead>
<tr>
<th>Time</th>
<th>Samples taken</th>
<th>Material</th>
</tr>
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<tbody>
<tr>
<td>Pullet-rearing</td>
<td></td>
<td></td>
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<tr>
<td>Day-old&lt;sup&gt;ad&lt;/sup&gt;</td>
<td>Per delivery</td>
<td>5 transport crates from one delivery: Crate liner (&gt; 1 m² in total) or swab samples (&gt; 1 m² in total) (Analysed as one pooled sample).</td>
</tr>
<tr>
<td>4 weeks old&lt;sup&gt;bd&lt;/sup&gt;</td>
<td>Per flock</td>
<td>5 pairs of boot swabs (analysed as two pooled samples) or 5 faeces samples of 60 gram.</td>
</tr>
<tr>
<td>2 weeks before moving&lt;sup&gt;ac&lt;/sup&gt;</td>
<td>Per flock</td>
<td>5 pairs of boot swabs (analysed as two pooled samples) or 5 faeces samples of 60 gram. 60 blood samples (serology).</td>
</tr>
<tr>
<td>Table egg layers (Production for certified packing stations)</td>
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<td></td>
</tr>
<tr>
<td>24 weeks old&lt;sup&gt;ac&lt;/sup&gt;</td>
<td>Per flock</td>
<td>2 pairs of boot swabs (analysed as one pooled sample) or 1 faeces sample consisting of 2x150 gram. 250 ml (100 g) dust or 1 pair of boot swabs. 60 eggs&lt;sup&gt;b&lt;/sup&gt; (serology).</td>
</tr>
<tr>
<td>Every 9 weeks&lt;sup&gt;de&lt;/sup&gt;</td>
<td>Per flock</td>
<td>2 pairs of boot swabs (analysed as one pooled sample) or 1 faeces sample consisting of 2x150 gram. 60 eggs&lt;sup&gt;b&lt;/sup&gt; (serology).</td>
</tr>
<tr>
<td>Barnyard and hobby flocks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Every 18 weeks&lt;sup&gt;d&lt;/sup&gt;</td>
<td>Per flock</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>) Sampling requirements set out by Regulation (EC) 2160/2003.
<sup>b</sup>) According to Order no 1260 of 15/12/2008.
<sup>c</sup>) Samples collected by the Regional Veterinary and Food Control Administration.
<sup>d</sup>) Samples collected by the food business operator.
<sup>e</sup>) According to Regulation (EC) 2160/2003 sample collection must be carried out every 15 weeks as a minimum.

Source: Danish Veterinary and Food Administration
Serological testing of egg yolk - the key to succes

• Mix-ELISA using LPS from S. Enteritidis and S. Typhimurium
• Samples are defined as seropositive if the calculated OD% > 40; specificity = 0.999
• Flocks are defined as seropositive if two or more samples are seropositive; specificity = 0.997
Receipt and registration in laboratory
Punching a hole (so the tip can get in)
Drawing egg yolk
ELISA testing
Salmonella control in breeders and laying hen flocks

- Serological positive samples
  - Under suspicion
  - Re-testing
- Infected central-rearing, parent flocks and rearing flocks
  - Slaughtered
- Infected/suspected table-egg layers
  - Intensive sampling for bacteriological testing
  - Eggs are heat-treated (pasteurisation)
  - Flocks and eggs from flocks are destroyed if:
    - Symptoms of salmonellosis
    - Infected with DT104
Effect of Salmonella control program in table-egg production
Occurrence of *Salmonella* in Danish table egg production
Human health benefits
Egg associated human salmonellosis in Denmark, 1988-2009

National surveillance

Cases per 100,000 inhab.
Public costs of the Danish salmonella control program in table-egg production

Surveillance costs assumed by industry (estimated)

Surveillance costs
Replacement costs

X 1000 €

1997
1998
1999
2000
2001
2002

0
500
1000
1500
2000
2500
3000
3500
4000
4500
Ten-year cost-benefit assessment
SE control in eggs in DK (1997-2006)

• 1997: ~ 3,000 registered egg associated cases
• 2006: ~ 100 registered egg associated cases

• Avoided societal costs: 23.3 mio. € (31.5 mio. $)
  – Lost labour and health care
• Public control costs: ~12-13 mio. €

• Continuously decreasing cost-benefit ratio
Antibiotic use in the danish poultry production

- 0.04 \( \text{ADD}_\text{kg} \) (DK layers)
- 0.15 \( \text{ADD}_\text{kg} \) (DK broilers)
- 5.0 \( \text{ADD}_\text{kg} \) (NL broilers)

No use of vaccines in DK or in imported breeders
All eggs to be salmonella-free

Denmark receives a special allowance from the EU to require all egg imports to be free of salmonella bacteria.

European Union health authorities okayed a Danish application for ‘special status’ that will ensure all eggs imported to the country are guaranteed by their distributors as being 100 percent salmonella-free.

Eva Kjer Hansen, the food and veterinary minister, called the approval from Brussels a ‘breakthrough’ and said Denmark would also be seeking special status for chicken imports as well.
EU baseline study of SE in holdings of laying hens 2004-2005

Figure 1. Observed prevalence of *Salmonella*-positive holdings of laying hens, with 95% confidence intervals, in the EU, 2004-2005
Recipee for successful control of SE in eggs in Denmark
Conclusions

• Control of Salmonella in table egg and broiler production highly successful

• Top-down eradication strategy feasible

• No need for antimicrobials, vaccines and other anti-infectives

• No need for post-harvest control if on-farm control is effective

• Major public health benefits

• Cost-beneficial
Publications


Thank you for your attention!