Danish approach to control of salmonella in cattle

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Denmark

5.5 million people, 1.2 million in Copenhagen
~12.3 million pigs
~1.5 million cattle, ~540,000 slaughtered cattle, ~3000 dairy farms
Development and source attribution of human cases 1988-2015

Figure 1.1. Total incidence of human salmonellosis and estimated human incidence due to domestic broilers, pork, table eggs and imported meat products in Denmark, 1988 to 2015.

Source: Danish Zoonosis Centre, National Food Institute.

>70% from travel/import in 2015
Source attribution salmonella
Denmark 2015

Figure 1.2. Estimated sources of 925 cases of human salmonellosis in Denmark, 2015. (See also Appendix Table A1)

- Sporadic cases, source unknown (20.0-27.4%)
- Outbreak cases, source unknown (2.3%)
- Domestic pork (1.8-6.5%)
- Domestic beef (0.3-2.5%)
- Imported pork (3.8-9.3%)
- Imported broilers (1.0-5.3%)
- Imported turkeys (0.1-3.0%)
- Imported duck (0.6-2.9%)
- Travel (55.8-57.1%)

Source: Danish Zoonosis Centre, National Food Institute.

No human cases attributed to domestic eggs and poultry in 2015
Estimated burden of salmonella disease: 348-401 DALYs – disability adjusted life years
Serotype distributions in human cases
Denmark 2014-2015

Table 1.1. Top 10 Salmonella serotypes in humans and information about travel abroad, 2014-2015

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<tr>
<th></th>
<th>Number of patients (%)</th>
<th>% of patients(^a) infected abroad(^b)</th>
<th>Domestically</th>
<th>Number of patients (%)</th>
<th>% of patients(^a) infected abroad(^b)</th>
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<td>Enteritidis</td>
<td>258 (27.9)</td>
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<td>Enteritidis</td>
<td>268 (23.9)</td>
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<td>1,4,[5],12:i:-</td>
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<td>34.3</td>
<td>65.7</td>
<td>1,4,[5],12:i:-</td>
<td>230 (20.5)</td>
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<td>Typhimurium</td>
<td>116 (12.5)</td>
<td>32.7</td>
<td>67.3</td>
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<td>50.0</td>
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<td>Stanley</td>
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<td>Other serotypes</td>
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<td>Total</td>
<td>925 (100)</td>
<td>56.6</td>
<td>43.4</td>
<td>Total</td>
<td>1,122 (100)</td>
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\(^a\) Patients with unknown travel information (17.3 of all patients in 2014 and 28.8 of all patients in 2014) were excluded from the percent calculations.

\(^b\) Infected abroad is defined as travel abroad in a seven-day period prior to disease onset.

Source: Statens Serum Institut.
Salmonella Dublin in humans in Denmark

Estimated burden of disease
Cattle: 24-30 DALYs in 2014 < 10% of total Salm. – DALY (Pires, report 2014)
Age distribution of *S.* Dublin human cases
Survivors and dead within 30 days

Source: Steen Ethelberg, SSI – includes all cases from 1990 and up to 2015
Yellow = all cases  Gray = dead within 30 days  Case fatality risk close to that of listeriosis
Fresh meat surveillance at slaughter

Figure A4. Salmonella in beef, monitored at slaughterhouses\(^a\), 2009-2015

- % positive
- % positive, moving avg. for 12 month

\(^a\) For more information about the surveillance programme, see Table A36.
Source: Danish Veterinary and Food Administration.
# Intensified bacteriological surveillance of persistently antibody positive cattle herds 2014-2017

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<th>Herd type</th>
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<th>Typhimurium</th>
<th>Other</th>
<th>S_4,12:i / S_4,5,12:i:-</th>
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Not random sample, but not ‘only passive surveillance’– see later
# Bacteriological culture results from passive surveillance (clinical suspicion) 2014-2017

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<th>Serotype</th>
<th>Number of isolates</th>
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<tr>
<td><strong>Total</strong></td>
<td><strong>21</strong></td>
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(SEGES)
How much ‘serogroup-B’ in the Danish dairy cattle?
Bulk tank milk samples tested with 2 tests at DTU-Vet
in master thesis project 2015
(Acknowledgements: Elisabeth Toft)

Test results for all samples

Group B ELISA results (ODC%) vs Group D ELISA results (ODC%)

n = 193
Conclusions from Elisabeth Toft’s project

- Salmonella serogroup B causes some ‘misclassification’ of Dublin-test-positive dairy herds
- Estimated to be 6.2-13% of the serogroup-D test-positive
- Corresponds to the bacteriological culture results from intensified surveillance
- Not possible to differentiate between serotypes based on serogroup D alone
- Not always clear distinction with two tests (B and D) either

Future – consider including more serotypes in the testing??
Currently not the plan – very few are missed.
Salmonella Dublin in cattle

- Bloody diarrhoea
- Loss of appetite
- Depression
- Fever + dehydration
- Septic shock
- Necrotic skin and bone
- Arthritis
- Pneumonia
- Abortions

- Few persistent carriers
- Many cattle infected without clinical signs
Bulk tank milk ELISA after introduction of *Salmonella* Dublin-infection in dairy herds
Milk losses related to introduction of *Salmonella* Dublin

kg ECM per day in 3 parity groups in 28 newly infected dairy herds

Signs of long-term milk losses in some cows

(Nielsen T.D. *et al.* JDS, 2012)
Economic consequences in S. Dublin infected dairy herds

*Salmonella* Dublin Simherd model estimations
Economic consequences in S. Dublin infected dairy herds

*Salmonella* Dublin Simherd estimations based on project data

Not unusual that the gross margin drops with 100-200 Euro per cow-stall the first 2-3 years after the infection is introduced.

Large herd – proportionally larger losses
Up to €35,000 lost annually (per 200 cow-stalls)

Pride

Milk yield losses

‘Let’s hope it is not salmonella’

More treatments --> antibiotic resistance?

Human health

Abortion

Food safety

Economics

More work

Pride

Reputation

More trouble

Animal health

Calf mortality
Surveillance programme for S. Dublin since 2002

Level 3 Salmonellosis / bacteria detected

Level 2 Test-positive
BTM > 25 ODC% in last 4 samples, 
+ no jump of 20 from 3-BTM average
Or: 8 blood samples, none above 50 ODC%

Level 1 Test-negative

- Dairy herds: 3-4 bulk tank milk antibody tests
- Non-dairy herds: 8-10 antibody tests on blood samples
- Movements of animals
- Locking system (3 weeks)
- Classification information www.glr-chr.dk
## Besætningsoplysninger

**Veterinære problemer:** Nej  
**Ejers oplysning om fødevarekædeoplysninger OK:** Ja  
**Salmonella Dublin niveau:** Niveau 1a siden 09-09-2011: Sandsynligvis salmonella dublin fri, på basis af tankmælksprøver
Eradication programme since 2007

Goal:
The Danish cattle population free from *Salmonella* Dublin in 2016

Three phases

1. 2007-2009
Voluntary intervention and evaluation. Projects.

2. 2010-2012
Restrictions to improve motivation

3. 2013-2016
Veterinary Authorities handle infected herds through law enforcement (regionalisation)
Target:
Eradication from the cattle population by end of 2016

Follow the development at www.kvaegvet.dk
Regionalisation since 2013

Regionalisation since 2015

No movement of cattle from HP to LP (except calves for fattening + slaughter)
High prev-region Level 1 herds must pre-test before participating in shows
Phase 3 – intensified control

- Level 2+3 in low-prevalence region put under official veterinary supervision - restrictions similar to Sweden
- All Level 2+3: Must have a **herd-specific control action plan**
  Usually developed with local veterinarian/advisor
  **Strict movement restrictions** out of these herds
  No participation in animal shows
- Level 1 farms in high-prevalence regions cannot more cattle to low-prevalence region (few exceptions)
- Level 2+3 can have free second opinion and advice from SEGES
Free, voluntary second opinion from SEGES on salmonella control in test-positive farms

Nu tror jeg på vi bliver fri for Salmonella Dublin

Poul Henrik Søgaard fik for alvor øjnene op for, hvor han og medarbejderne skal lægge indsatsen efter besøg af SEGES’ salmonellaekspert.

I 2015 fik Poul Henrik Søgaard konstateret Salmonella Dublin i sin besætning, som består af 425 Dansk Holstein-årskør. Årsagen var indkøb af en tyr, som viste sig at være smittet.


"Betina gennemgik besætningen sammen med min dyrlæge og jeg. Og her gik det virkelig op for mig, at det er godning, der er den helt store synder i det her spil," forklarer han.

"Og det var nok også først ved hendes besøg, at det gik op for mig, hvor alvorligt det her er – dels hvor meget det koster og dels, at vi hurtigt risikerer at hele besætningen er smittet," forklarer han.

Nye og faste rutiner

På Betina Tvistholms anbefalinger har han og de seks medarbejdere nu ændret en del arbejdsrutiner og sat dem i system. Blandt andet er de 100 pct. konsekvente med kun at flytte dyr i hold. Og de har helt faste rutiner omkring rengøring og desinfektion af især kalveboks og hos opstarterhold.
Phase 3 – intensified testing

After 1 year in Level 2 (test-positive in surveillance)

- Effect of control actions must be documented
- 8 samples from the youngest calves >3 months old every 3 months
- If test-positive calves -> bacteriological culture Calves, high-risk animals + slurry
- If culture positive -> Level 3 (economic consequences due to movement and slaughter restrictions)
Regional development of test-positive dairy herds (Level 2+3)
Non-dairy herds
- surveillance based on the last 8 blood samples
(ELISA – cut-off 50 ODC%)

More frequent sampling

Large fattening herds (>100)
Heifer raising herds
Small fattening herds (<100)
National average
Purebred beef herds

www.kvaegvet.dk
National prevalence is declining

25% -> 7-8% test-positive dairy herds from 2003 to 2016
42% -> 17% test-positive large slaughter calf herds 2007-2016

Bull calves from Level 2 much cheaper
Today very difficult to sell in DK
Source herds of calves to large fattening herd in 2015

Tranbjerg Østergaard A/S
3320 kalve købt siden 1.1.14
**New tool for fattening herd owners**

List of source herds with salmonella and calf mortality

Need permission from dairy herds to extract calf mortality and BTM results

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Challenges
Structural development over 20 years

Important risk factor for infectious disease spread: Herd size!
Biosecurity
- not an overly popular conversation topic
Future changes to the programme?

??? Not decided yet
Negotiations ongoing

- Mandatory control effort in test-positive herds
- Mandatory follow-up on calves 8 blood samples every 3 months
- Continued testing 1-2 years after becoming Level 1?

Control campaign vet authorities
Mandatory secondary advisory, if no effect of control efforts

From end of 2019:
All test-positive herds under official veterinary supervision
(closed herds, special hygienic slaughter)
Genetic clusters and circulation of *Salmonella* Dublin in Jutland

Leonardo V. de Knecht, Egle Kudirkienė, Gitte Sørensen, Liza R. Nielsen, John E. Olsen

**BACKGROUND**
- Danish *S. Dublin* surveillance program
- National eradication programme initiated
- Enforced trade restrictions in legislation
- Mandatory control and strict trade restrictions

**OBJECTIVE**
To use whole genome sequencing (WGS) to improve the understanding of strain circulation between herds

**METHODS**
- *S. Dublin*: 197 isolates from 56 herds 1996 to 2016
- Sequencing: MiSeq 250 bp pair-end
- Assembly/Annotation: SPAdes 3.6.1, Prokka 1.0
- Population structure analysis: CSI Phylogeny
- Genome content analysis: Roary/Scary
- Movement of cattle between herds since 1960: from Danish Cattle Database

**RESULTS**
- Core genome clusters
- Plasmid profiling
- Cluster I: Mid- and South Jutland
- Cluster II: mostly North, heavily enriched by plasmids
- Cluster III: highly distant, may be ancestral Danish strains

**Location of herds by cluster and plasmid profile (colours)**

- Cluster I
- Cluster II
- Cluster III
- Markets

**Example of movement network**
- Trade network centered around markets
- Key herds indicate possible contact points between Clusters II and III
- Plasmid sharing highlights non-visible contacts between genomically different or trade-isolated herds
- Core genome differences discern false circulation nodes
- Serology helps discard negative intermediaries

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Thank you for your attention