Options, cost and effect of salmonella control in pigs and pork

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• Options
• Data
• Correlation between salmonella in primary production and on the slaughterhouse
• Cost and effect of interventions
• Relevant target
  • Primary production
  • Carcass
Options

• Primary production
  • Eradication
  • Reduction
• Slaughter house
  • Improved hygiene
  • Decontamination
    • Chemical
    • Physical (hot water, steam)
    • Other
Cost-effect calculations

- Target arbitrarily set at 3% positive swab pools (=1% positive carcasses)
- Cost to reach target under different slaughterhouse sizes and initial prevalences
- 15 years time-horizon to even out effect of high starting cost or high maintenance cost
- No discounting is done
Data

- Pooled swab samples
  - 5 carcasses pr pool
- Danish movement database
- Meat-juice results
Data II

- **Period**
- **38336 swaps**
  - Full data on 17180 swab samples
    - Serological data on each of the 5 herds in pool
    - Serological data on pigs delivered same day, but not part of pool
- **22 slaughterhouses**
- **>9000 herds**
- **>100 million pigs**
- **>2 million serological tests**
  - Cutoff for positive sample 30 OD% (not the cutoff used in surveillance)
- **Herds classified using 1 years samples**
### Pool positivity depending on serological status of herds represented in the pool

<table>
<thead>
<tr>
<th>Positive herds in the pool</th>
<th>Positive pools</th>
<th>Negative pools</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>88 (4.4 %)</td>
<td>1895</td>
<td>1983</td>
</tr>
<tr>
<td>4</td>
<td>135 (4.9 %)</td>
<td>2642</td>
<td>2777</td>
</tr>
<tr>
<td>3</td>
<td>166 (4.18 %)</td>
<td>3809</td>
<td>3975</td>
</tr>
<tr>
<td>2</td>
<td>122 (3.14 %)</td>
<td>3767</td>
<td>3889</td>
</tr>
<tr>
<td>1</td>
<td>85 (3.13 %)</td>
<td>2634</td>
<td>2719</td>
</tr>
<tr>
<td>0</td>
<td>38 (2.07%)</td>
<td>1799</td>
<td>1837</td>
</tr>
<tr>
<td>Sum</td>
<td>634 (3.69 %)</td>
<td>16546</td>
<td>17180</td>
</tr>
</tbody>
</table>
Association between number of seropositive pigs on the slaughterday and risk of pool positivity
Results of statistical analyses

Carcass positivity is function of:

- Serological herd status of carcasses in pool
- Serological status of pigs other pigs (cross-contamination)
  - Increasing risk up to 40 seropositive pigs pr day
  - No increase after 40
- Slaughterhouse
  - Probably a reflection of hygiene

(and in rare events a "house-infection", not found here).
Primary production-scenarios

• Eradication – increasing number of negative herds
• Reduction-reducing prevalence in positive herds
Primary production

- Scenario 1, eradication at herd level
  - Eradication will include genetic-, sow- and finisher herds
  - Reduction in number of seropositive herds
  - No reduction of number of positive pigs in positive herds (7.5%)
  - 4 slaughter-house sizes
  - 4 starting herd prevalences
  - Deterministic model
  - Target set at 3 % positive pools
<table>
<thead>
<tr>
<th>Slaughterhouse size</th>
<th>Initial herd prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10%</td>
</tr>
<tr>
<td>200</td>
<td>0</td>
</tr>
<tr>
<td>1000</td>
<td>0</td>
</tr>
<tr>
<td>5000</td>
<td>0</td>
</tr>
<tr>
<td>10000</td>
<td>0.00%</td>
</tr>
</tbody>
</table>
Cost pr pig slaughtered

- Cost based on accurate Danish figures from the DT104 program
  - 79 Euro pr depop – repop pig year 1
  - 3 Euro pr depop-repop pig following years
Cost pr pig slaughtered year 1/following year/average over 15 years to achieve target

<table>
<thead>
<tr>
<th>Slaughterhouse size</th>
<th>Initial herd prevalence</th>
<th>10%</th>
<th>20%</th>
<th>40%</th>
<th>60%</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td></td>
<td>0/0/0</td>
<td>0/0/0</td>
<td>0/0/0</td>
<td>0/0/0</td>
</tr>
<tr>
<td>1000</td>
<td></td>
<td>0/0/0</td>
<td>0/0/0</td>
<td>0/0/0</td>
<td>16/1/2</td>
</tr>
<tr>
<td>5000</td>
<td></td>
<td>0/0/0</td>
<td>6/0.3/0.7</td>
<td>22/1/2</td>
<td>38/2/4</td>
</tr>
<tr>
<td>10000</td>
<td></td>
<td>0/0/0</td>
<td>8/0.3/1</td>
<td>24/1/2</td>
<td>39/2/4</td>
</tr>
</tbody>
</table>
Problems

- Who decides which herds are to undergo depop-repop
- Who pays
Scenario 2, reduction at herd level

- Number of positive herds unchanged
- Reduction in sero-prevalence in positive herds
- 4 slaughterhouse sizes
- Initial herd prevalence 50%
- Initial average within-herd prevalence in positive herds 7.5%
## Cost to reach target

<table>
<thead>
<tr>
<th>Slaughter-house size</th>
<th>Proportion of pigs in reduction program to achieve target</th>
<th>Cost pr produced pig pr year</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>0%</td>
<td>-</td>
</tr>
<tr>
<td>1000</td>
<td>4%</td>
<td>0.08</td>
</tr>
<tr>
<td>5000</td>
<td>30%</td>
<td>0.60</td>
</tr>
<tr>
<td>10000</td>
<td>40%</td>
<td>0.80</td>
</tr>
</tbody>
</table>
Can this be achieved?

- Danish experience and Danish research have shown, that it is extremely difficult to reach a near zero prevalence in positive herds.
- A herd reduction scenario will not reach the target for large slaughterhouses
Improved hygiene
Slaughterhouse effect corrected for salmonella input – effect of hygiene

![Graph showing the relationship between Slaughterhouse size and Odds ratio]

- X-axis: Slaughterhouse size
- Y-axis: Odds ratio

The graph illustrates the odds ratio for different sizes of slaughterhouses, indicating how hygiene measures can influence the occurrence of salmonella.
Effect of improving the hygiene to level of the 5 slaughterhouses with the best result
Improved slaughter hygiene

• Target can be reached, if all slaughterhouses can achieve results similar to the results from the best 5 slaughterhouses (excluding the smallest one)

• Costs will be very different from slaughter house to slaughter house
Decontamination
Decontamination

• Only physical decontamination relevant at the moment
• One facility based on hot water has been in operation for several years
• Steam and steam combined with ultrasound under investigation

• These calculations are based on results from the hot water wash
Hot water wash
More than 90% reduction of positive carcasses
### Cost of decontamination (Euro)
(max capacity for 1 device=750,000 pigs pr year)

<table>
<thead>
<tr>
<th>Slaughter-house size</th>
<th>Annual kill</th>
<th>Initial cost</th>
<th>Running cost pr pig</th>
<th>Cost year 1 pr pig</th>
<th>Average expence 15 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>48,000</td>
<td>333,333</td>
<td>0.60</td>
<td>8</td>
<td>1.07</td>
</tr>
<tr>
<td>1000</td>
<td>240,000</td>
<td>333,333</td>
<td>0.32</td>
<td>2</td>
<td>0.42</td>
</tr>
<tr>
<td>5000</td>
<td>1,200,000</td>
<td>666,667</td>
<td>0.15</td>
<td>1</td>
<td>0.18</td>
</tr>
<tr>
<td>10000</td>
<td>2,400,000</td>
<td>1,000,000</td>
<td>0.15</td>
<td>1</td>
<td>0.17</td>
</tr>
</tbody>
</table>
Conclusion 1

• Cost-effective salmonella control dependant on
  • Herd prevalence
  • Sector structure
  • Slaughterhouse size

• Small slaughterhouses, low prevalence
  • Herd interventions cost effective

• Large slaughterhouses, high prevalence
  • Slaughterhouse interventions cost effective
Conclusion 2

- Targets should be set on carcass level, not on herd level
  - Targets on breeding pigs and slaughter pigs is poorly correlated with carcass level and human health
Conclusion 3

- Cost-benefit analyses have to be done, or to incorporate country/region differences
  - Herd prevalence
  - Herd and slaughterhouse structure
Conclusion 4

- Experience from Denmark
  - Herd reduction can only reduce the level from high to medium
  - Almost impossible to measure an effect on the slaughterhouse/human cases
- Research is needed to get new tools for reduction
  - At herd level
  - At slaughterhouse level
Conclusion 5

• Cost-benefit-analyses are only meaningful on a chain level
  • "Good economic models cannot compensate for bad biological models"