Pork and the number of human multi-resistant Salmonella Typhimurium DT104 cases

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Summary: As part of a revision of the Danish Salmonella policy, we estimated the impact of nationally produced pork compared to imported pork on the number of human sporadic domestic cases of multi-resistant Salmonella Typhimurium DT104 (MRDT104) in Denmark. We also estimated the number of deaths related to the presumed excess mortality associated with MRDT104. Data on exposure from domestic and imported pork were built into a simple simulation model in @Risk, and Monte Carlo simulations were used. Our results showed that imported pork resulted in 20 times as many human cases as domestic (2 human cases per year), and 1 extra death in 50 years. If the prevalence of MRDT104 in domestic pork increased 5 times, the absolute number of human cases (related to Danish pork) would be 8-11. The excess mortality due to this rise in human cases will be negligible compared to the mortality caused by other Salmonellae.

Keywords: food safety, human health, risk assessment, surveillance, trade

Introduction: Multi-resistant Salmonella Typhimurium DT104 (MRDT104) is of primary interest in many countries because of concern for human health. It has been suggested, that MRDT104 is associated with an excess mortality among humans. In Denmark, an eradication policy was initially carried into effect in the swine sector. This policy, among others, included depopulation of affected swine herds and mandatory bacteriological follow-up in herds with high levels of antibodies against Salmonella. MRDT104 spread despite the extensive means taken.

As part of a revision of the Danish Salmonella policy, we were interested in estimating the impact of nationally produced pork compared to imported pork on the number of human sporadic domestic cases of MRDT104 occurring in Denmark. We also wanted to estimate the number of deaths to expect because of the presumed excess mortality associated with MRDT104.

Materials and Methods: Data on exposure from domestic and imported pork were compared. Exposure was measured as the product between the relative amounts of pork consumed and the prevalence of MRDT104 in domestic and imported pork, respectively. Data describing Salmonella prevalence, the prevalence of MRDT104, and the number of human cases covered the time period 1998 to 2002. A simple simulation model was built in @Risk, and Monte Carlo simulation with 10,000 simulations was used. Pert distributions (with minimum, mode, and maximum) were used for all input parameters (Table 1).
The number of human deaths due to the presumed excess mortality was estimated based on published results from Helms et al. (2002), as modified by Dahl (2003). These results showed, that the excess risk of dying was nearly significant ($p=0.06$) for cases caused by penta-resistant MRDT104, when including quinolone-resistant isolates, compared to cases caused by susceptible isolates (neither penta-, nor quinolone-resistant) (Table 2). When cases caused by quinolone-resistant strains were excluded, there was no significant excess mortality for penta-resistant MRDT104, compared to susceptible isolates ($p=0.55$).

Assuming, that penta-resistant MRDT104 causes an excess mortality, even though it is not significant, we can estimate the excess number of human deaths caused by penta-resistant MRDT104, excluding the effect of background mortality and the mortality due to salmonellosis in general. Helms found, that the background mortality in the human control population was 1.1 % for 2 years. Using the relative risk (RR) estimates from Table 2 gives a mortality in the susceptible group of $1.1\% \times 2.1 = 2.3\%$. In the penta-resistant, quinolone-susceptible group this figure is $1.1\% \times 2.9 = 3.2\%$. The excess mortality due to penta-resistance is then $3.2\% - 2.3\% = 1\%$.

### Table 2. Two-year relative death risks of 2,047 Danish patients infected with Salmonella Typhimurium, by antimicrobial susceptibility pattern. 1995-1999 (Helms et al., 2002, modified by Dahl, 2003)

<table>
<thead>
<tr>
<th>Resistance isolates</th>
<th>Pattern</th>
<th>Deaths/cases</th>
<th>RR* (C. I.)</th>
<th>P-value b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penta including quinolone</td>
<td>12/283</td>
<td>4.8 (2.2-10.5)</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Penta with quinolone</td>
<td>5/40</td>
<td>13.1 (3.3-51.9)</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Penta without quinolone</td>
<td>7/243</td>
<td>2.9 (1.1-7.9)</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>Susceptible S. Typhimurium</td>
<td>47/1764</td>
<td>2.1 (1.5-2.9)</td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>

aDeath risk relative to the general population (random matched sample of 20,456 Danes), adjusted for co-morbidity (Helms et al. 2002). bComparison of RR with susceptible S. Typhimurium isolates (last row)

### Results:

According to the model, imported pork resulted in 20 times as many human cases as domestic. The model was validated against the Danish Zoonosis Centre’s model, which produced similar results. By use of the ratio between MRDT104 and Salmonella spp. identified in pork in Denmark, it was estimated, that Danish pork was responsible for 1.6-2.2 (1.6-2.2) human domestic cases of MRDT104 per year. If the prevalence of MRDT104 in domestic pork increased 5 times, the absolute number of human cases (related to Danish pork) would be between 8 and 11 cases.

The 2 human domestic cases both have an excess mortality of 1 % caused by MRDT104. This means that MRDT104 in Danish pork causes one extra death in 50 years at the present level.

### Discussion:

The Danish swine industry has invested a total of 20 million Euro – hereof 4 millions in year 2002 – on surveillance and control of MRDT104. This amount should be seen in relation to the 8 million Euros spent annually on Salmonella reduction in pigs and pork. The industry has committed itself to reducing the prevalence of Salmonella by 27.5 % in the next 5 years.
A lift on the strict regulation on MRDT104 will most likely result in an increase in the number of human cases. Such an increase will to some extent be counteracted by the industry’s general effort against Salmonella. Even with a substantial increase in the MRDT104 prevalence in the pig production, the excess mortality due to this source will be negligible, when the total number of human Salmonella cases ascribed to pork is as low as it is in Denmark (163 reported cases in 2001, 77 in 2002).

**Conclusion:** This study demonstrates the importance of focusing on the absolute size of a problem in order to allocate resources most cost-effectively in a national surveillance-and-control programme.

**References:**

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**O 35 Estimated society cost for pork-related Salmonella and Yersinia in Denmark 2002**

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**Summary:** The Danish society costs for human gastroenteritis from pork related Salmonella and Yersinia have been estimated for 2002. The expenses for the veterinary salmonella-program in 2002 are calculated to 6.9 million Euro. The registered human cases only represent the more severely affected human cases; the total number of human cases might be 5 to 20 times higher. The registered salmonellosis and yersiniosis cases are assumed to have lost 8 and 7 working days through sickness; whereas the not registered cases are assumed to have lost 2 working days, respectively. The Danish society costs in 2002 for pork related salmonellosis and yersiniosis due to gastroenteritis are estimated to 0.16 – 0.59 million Euro and 0.32 – 1.3 million Euro, respectively. Between 70-90% of the society expenses are due to lost days of work.

**Keywords:** zoonoses, swine, lost days of work, public health economy

**Materials and methods:** The aim of the study is to estimate the Danish society costs for human gastroenteritis from pork related Salmonella and Yersinia in 2002, the effect of the control programs on the number of infected Danes and the amount of saved society expenses from 1994 to 2002. Sequelae, chronic health effects and premature death are not included in the estimates.
A national Salmonella surveillance and control program for swine have been implemented in Denmark since 1995 (Nielsen et al. 2001). The level of Salmonella is controlled at various stages: feedstuffs, breeder and multiplier herds, weaner-producers, finisher herds and at the slaughterhouse. The registered human incidence of pork related salmonellosis has declined from 22 per 100,000 inhabitants in 1993 to 1.4 per 100,000 in 2002 (Anonymous 2003). The expenses for the veterinary salmonella-program in 2002 were calculated to 6.9 million Euro, of which the swine industry covers 92%. No specific veterinary Yersinia control program exists in Denmark. However, slaughter hygiene has steadily been improved during the last decade and is considered to have reduced the prevalence of Yersinia in pork. The registered human incidence of Yersiniosis has declined from 14 per 100,000 inhabitants in 1993 to 3.8 per 100,000 in 2002 (Anonymous 2003). There is no source account for human yersiniosis in Denmark, but we assume that at least 80% of the Yersiniosis cases are food borne (Mead et al 1999), and that all originate from Danish pork. However, the registered human cases only represent the