SHORT REPORT

Meningitis, sepsis and endocarditis among workers occupationally exposed to pigs

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Background Workers exposed to pigs can develop meningitis, sepsis or endocarditis due to infection with Streptococcus suis transmitted from pigs to man.

Aims To estimate the risk of these diseases.

Methods We used the Occupational Hospitalization Register (OHR) which holds information about occupation and hospital treatments for all adults in Denmark. A dynamic population of male workers exposed to pigs was identified every year from 1995 to 2006 by occupational and industrial groups. First hospital treatment or death in the following year due to meningitis, sepsis or endocarditis was identified by ICD-10 codes from the OHR. By comparison with all other economically active men in Denmark, the standardized incidence ratio (SIR) was calculated for these diseases.

Results Among those exposed, we observed 32 cases of meningitis, sepsis and endocarditis during 140 118 person-years. In the reference group, we observed 2680 cases during 15 209 394 person-years. The SIR of the exposed group was 1.35 (95% CI: 0.95–1.92). Among the 32 cases, 7 cases of meningitis and sepsis were specified as caused by infection with streptococci. The SIR for these seven cases was 2.4 (95% CI: 1.1–5.0).

Conclusions Our study did not find that workers exposed to pigs had an overall increased risk of developing meningitis, sepsis or endocarditis.

Key words Health risks; occupational exposure; pigs; Streptococcus suis; zoonoses.

Introduction

The first report of meningitis and sepsis due to Streptococcus suis spread from pigs to humans came from Denmark in 1968 [1]. Since then, several hundred cases of S. suis infections mainly in workers occupationally exposed to pigs have been reported worldwide [2].

Reviewing 30 cases of S. suis meningitis in The Netherlands, Arends and Zanen estimated the annual incidence to be 3 per 100 000 workers in slaughterhouses and in pig farms [3]. Two of the 30 with the disease died. Many of those infected had sequelae and ~50% developed severe hearing impairment. Streptococcus suis as a cause of endocarditis and septic shock has also been reported in case reports [4,5].

Compared with the large number of workers exposed to S. suis, the number of reported cases of serious infection is small. The true incidence might be higher due to misclassification [4].

The aim of the study was to evaluate the risk of these diseases in workers occupationally exposed to pigs.

Methods

A dynamic population of all economically active 20- to 59-year-old men in Denmark was followed over the period 1995–2006 for hospital treatment or death due to meningitis, sepsis and endocarditis.

We used information in the Danish Occupational Hospitalisation Register (OHR), a database obtained through a record linkage between four national registers—the central person register, the hospitalization register, the cause of death register and the employment classification module [6].
A person was considered to be at risk if he was a pig farmer or a worker employed in a pig farm. A person was considered to be at risk if he was a lorry driver in a pig farm or slaughterhouse. A person was considered to be at risk if he was a slaughterhouse inspector, a butcher or other worker in a slaughterhouse slaughtering pigs.

Very few women were employed in the exposed job groups and we decided to exclude women from the analysis.

With the exception of men in the groups described above and men employed as lorry drivers, all 20- to 59-year-old economically active men in Denmark were used as the ‘unexposed’ reference population.

The study subjects were followed up in OHR 1995–2006 due to ICD-10 code for meningitis, sepsis or endocarditis (Table 1) either as the principal cause of death or the principal diagnosis of at least one hospital contact during the follow-up [7]. The follow-up ended on the date of diagnosis, date of death, date of emigration or at the end of study whichever came first. Person-years at risk (PYRS) were calculated for each individual.

With log(PYRS) as offset, we used Poisson regression to model the outcome as a function of exposure category (1 = ‘workers exposed to pigs’; 0 = ‘reference population’). The analysis was controlled for calendar year and age category (20–24, 25–29 ... 55–59 years).

Proc genmod in SAS version 9.1 was used to implement the analysis.

**Results**

Of those exposed, 25% were farm workers, 2% lorry drivers and 73% slaughterhouse workers. Among the exposed, we observed 32 cases in 140 118 person-years at risk (4 among the farm workers, 28 among the slaughterhouse workers and 0 among the lorry drivers). In the reference group, we observed 2680 cases in 15 209 394 person-years. The standardized incidence ratio (SIR) was 1.35 (95% CI: 0.95–1.9) for meningitis, sepsis and endocarditis among the exposed compared to the reference group.

Table 1 shows the distribution of diagnosis among cases in the study population.

After having seen the results, we calculated the SIR for ICD-10 codes specifying infection with streptococci. The SIR for infection with streptococci was 2.36 (95% CI: 1.1–5.0).

**Discussion**

We found a non-statistically significant increased risk of meningitis, sepsis or endocarditis among workers exposed to pigs. However, for meningitis and sepsis caused by streptococci, the risk was statistically significantly

<table>
<thead>
<tr>
<th>ICD-10 code</th>
<th>Diagnosis</th>
<th>Exposed to pigs, n (%)</th>
<th>Non-exposed, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A39.0</td>
<td>Meningococcal meningitis</td>
<td>70 (3)</td>
<td></td>
</tr>
<tr>
<td>A40.0</td>
<td>Septicaemia due to <em>Streptococcus</em>, Group A</td>
<td>51 (2)</td>
<td></td>
</tr>
<tr>
<td>A40.1</td>
<td>Septicaemia due to <em>Streptococcus</em>, Group B</td>
<td>1 (3)</td>
<td>10 (0)</td>
</tr>
<tr>
<td>A40.2</td>
<td>Septicaemia due to <em>Streptococcus</em>, Group D</td>
<td>2 (0)</td>
<td></td>
</tr>
<tr>
<td>A40.3</td>
<td>Septicaemia due to <em>Streptococcus pneumoniae</em></td>
<td>4 (13)</td>
<td>116 (4)</td>
</tr>
<tr>
<td>A40.8</td>
<td>Other streptococcal septicaemia</td>
<td></td>
<td>32 (1)</td>
</tr>
<tr>
<td>A40.9</td>
<td>Streptococal septicaemia, unspecified</td>
<td>1 (3)</td>
<td>72 (3)</td>
</tr>
<tr>
<td>A41.9</td>
<td>Septicaemia, unspecified</td>
<td>16 (50)</td>
<td>1406 (52)</td>
</tr>
<tr>
<td>G00</td>
<td>Meningitis not specified</td>
<td>8 (0)</td>
<td></td>
</tr>
<tr>
<td>G00.0</td>
<td><em>Haemophilus</em> meningitis</td>
<td>7 (0)</td>
<td></td>
</tr>
<tr>
<td>G00.1</td>
<td>Pneumococcal meningitis</td>
<td>153 (6)</td>
<td></td>
</tr>
<tr>
<td>G00.2</td>
<td>Streptococcal meningitis</td>
<td>1 (3)</td>
<td>19 (1)</td>
</tr>
<tr>
<td>G00.3</td>
<td>Staphylococcal meningitis</td>
<td>1 (3)</td>
<td>11 (0)</td>
</tr>
<tr>
<td>G00.8</td>
<td>Other bacterial meningitis</td>
<td>1 (3)</td>
<td>19 (1)</td>
</tr>
<tr>
<td>G00.9</td>
<td>Bacterial meningitis, unspecified</td>
<td>59 (9)</td>
<td>213 (8)</td>
</tr>
<tr>
<td>G01.9</td>
<td>Meningitis in bacterial diseases classified elsewhere</td>
<td></td>
<td>30 (1)</td>
</tr>
<tr>
<td>I33</td>
<td>Endocarditis not specified</td>
<td></td>
<td>1 (0)</td>
</tr>
<tr>
<td>I33.0</td>
<td>Acute and subacute infective endocarditis</td>
<td>2 (6)</td>
<td>322 (12)</td>
</tr>
<tr>
<td>I33.9</td>
<td>Acute endocarditis, unspecified</td>
<td>2 (6)</td>
<td>138 (5)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>32 (100)</td>
<td>2680 (100)</td>
</tr>
</tbody>
</table>
increased in workers exposed to pigs supporting our hypothesis of higher incidence of \textit{S. suis} infections in this group.

The strength of our study is that it includes all employees and all self-employed in Denmark and all death and hospital treatments during the follow-up period. Referral bias could be a problem. Taking the seriousness of the diseases in the study into consideration, we expect all to have been admitted to hospital. If they died before admission, they would be included via the Cause of Death Register.

A weakness of our study is that the exposed group may have included individuals who were not exposed and the reference group may have included individuals who were exposed. During the follow-up period, people may have changed from the exposed group to the reference group or vice versa. However, the exposure information was updated every year so the bias must be small.

We could not register cases of infections with \textit{S. suis} because there are no ICD10 codes for \textit{S. suis} infections. The incidence of \textit{S. suis} meningitis in subjects exposed to pigs has been estimated to be 3 cases per year per 100 000 workers [3]. Used in our study, this would mean 4.2 cases of \textit{S. suis} meningitis in the exposed group. We find it realistic that about four of the seven cases with streptococcal infection could be caused by \textit{S. suis}.

The exposed group could be healthier than the control group. The work of the exposed group involves high physical demands which would tend to select healthier subjects into the relevant trades and select disabled workers out of them. In the food production industry, there are also legal demands of health control of the employed [8]. This would indicate that the exposed group would be expected to have an a priori lesser risk of developing sepsis, endocarditis and meningitis.

Previous studies have shown that workers exposed to pigs can catch meningitis, sepsis or endocarditis due to infection with \textit{Streptococcus suis}. We did not find an overall increased risk of developing meningitis, sepsis or endocarditis in workers exposed to pigs.

**Conflicts of interest**

None declared.

**Key points**

- Previous case reports have shown that workers exposed to pigs can catch meningitis, sepsis or endocarditis due to infection with \textit{Streptococcus suis}.
- We followed up all 20- to 59-year-old male pig farmers, abattoir workers and haulage contractors in Denmark from 1995 to 2006 with respect to hospitalization for meningitis, sepsis or endocarditis.
- Our study did not find that workers exposed to pigs had an increased risk of developing meningitis, sepsis or endocarditis.

**References**