Quantitative risk assessment of human salmonellosis from the consumption of typical pork products in the Veneto Region of Italy

Barrucci, F.*, Cibin, V., Busani, L., Ricci, A.

National Reference Laboratory for Salmonella, Istituto Zooprofilattico Sperimentale delle Venezie, Italy
*corresponding author: fbarrucci@izsvenezie.it

Abstract

ARSIS is a pilot scheme commissioned by the Veneto Region aimed at evaluating the risk of salmonellosis for Veneto region inhabitants due to the consumption of ‘insaccati’, typical pork sausages. The quantitative risk assessment (QRA) approach was used to assess the risk of human salmonellosis and to estimate the number of cases in a year among Veneto inhabitants, divided into sex and age classes.

Introduction

Salmonellosis is one of the most common foodborne infections worldwide, and particularly Salmonella Typhimurium and Enteritidis are the serotypes more frequently isolated from humans (Herikstad H. et al., 2002). It is estimated that in 2004 S. Enteritidis caused 76% and S. Typhimurium caused 14% of human salmonellosis in the EU. It is generally accepted that infection caused by S. Enteritidis is related to poultry products and specially tables eggs. Important sources of S. Typhimurium infections are broiler meat, pig meat and cattle. Results from Denmark and The Netherlands indicate that the greater part of the human S. Typhimurium infections are attributable to pig meat (EFSA, 2006).

In the Veneto Region the situation in 2001 was different and opposite: 19% of the isolated strains were typed as S. Enteritidis while 41% were typed as S. Typhimurium (Enter-net Italy, http://www.sim.iss.it/EnterNet/index.asp).

Data from Enter-net Italy demonstrate that during the years 2000-2002 pig meat and pork products accounted for 6.6 to 12.3% of human reported and investigated cases of salmonellosis in Italy (Busani L., personal communication).

In Italy pork production is extremely varied and products are consumed both raw (riped sausages) and cooked (raw sausages and cuts of meat), in particular in the Veneto region the production as well as the consumption of both raw and ripened sausages is relevant. Therefore in 2002 Regione Veneto, as the institution in charge of safeguarding public health, commissioned a pilot scheme (denominated ARSIS) aimed at evaluating the risk of salmonellosis for Veneto region inhabitants due to the consumption pork sausages.

A risk model, based on a farm-to-fork approach, was developed to estimate the exposure to Salmonella from pork sausages and the number of human cases associated with this exposure.

Material and methods

Information and data for the development of the risk model were appropriately collected with a sampling scheme. The sampling was conducted at retails to estimate prevalence and concentration of Salmonella in both raw and ripened sausages. To determine the sample size necessary to estimate the frequency of contaminated sausages, we supposed an expected prevalence of 30% for raw sausages and 20% for ripened sausages. Sample sizes equal to 325 and 250 respectively were fixed to catch the expected frequencies with 95% confidence and 5% accuracy.

Moreover we supposed that the number of meat retailers and the amount of sold meat were proportional to the population living in a particular district, therefore the total number of samples was divided proportionally to the number of district residents.
When information was not available, published data were used to establish input settings for the model. Whenever possible, the data were represented by probabilistic distributions rather than single point estimates, as they were to be integrated in a probabilistic estimation of the risk using Monte Carlo simulation. The software R and @Risk have been used to estimate parameters and run simulations.

**Exposure assessment**

A mathematical models was developed to estimate the likelihood and magnitude of exposure to Salmonella due to the consumption of sausages. The framework of the model is described in figure 3.

![Figure 3: Framework of the model for the exposure assessment and for the risk characterization](image)

Using the collected data, the percentage of contaminated sausages at retails was modelled as a Beta distribution with parameters $\alpha=s+1$ and $\beta=N-s+1$, where $N$ is the total number of sausages and $s$ the number of contaminated sausages. The most appropriate distribution to describe concentration data was the Poisson distribution with estimated parameter $\lambda=0.161$ and $\lambda=0.085$ for raw and ripened sausages. To estimate the number of microorganisms to which consumers were exposed, we supposed that the weight of a portion is 50gr for raw sausages and 20gr for ripened sausages. For each iteration the exact number of organisms ingested $(n)$ was estimated and the probability that at least one of the $n$ organisms would infect the host could be determined as $P_{inf} = 1 - (1-p)^n$. We assumed that $p$ follows a Beta($\alpha, \beta$) distribution, taking into account variability between individual humans, that is we assumed that the dose-response relationship could be described by the Beta-Poisson model. For the Beta parameters we used the estimates proposed by Rose and Gerba (1991), $\alpha=0.33$ and $\beta=139.9$.

From the feeding trial data presented by McCullough and Eisele in 1957, the probability of infection followed by illness is between 0 and 75%. Because of the high doses administered in this study, in the present dose-response model it was assumed that independently of the dose ingested, if a person becomes infected, there is a reduced 10% probability that the person will become ill. The uncertainty on the probability of illness was described by a Beta distribution.

**Risk characterization**

The risk of salmonellosis from the consumption of a single portion of both raw and ripened sausages was estimated using the results of the previous steps.
The probability of exposure to Salmonella is obtained as one minus the probability of not being exposed to any Salmonella cells in a serving multiplied with the fraction of positive sausages. Given exposure, and the number of Salmonella cells, the probability of infection for each individual person from a serving is calculated. The probability of illness was calculated by multiplying the probability of infection with the probability of illness given the person has been infected.

In the present work we have not included the variability in the probability of getting illness from each individual serving containing Salmonella. Instead the average probability of getting illness was determined.

Finally, the frequency of consuming data were linked to census data (Table 1) to obtain the estimates of the number of human cases of salmonellosis associated with the consumption of sausages.

<table>
<thead>
<tr>
<th>AGE</th>
<th>MALE</th>
<th>FEMALE</th>
<th>% MALE</th>
<th>% FEMALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-5</td>
<td>84966</td>
<td>62046</td>
<td>53.1</td>
<td>50.3</td>
</tr>
<tr>
<td>6-14</td>
<td>159134</td>
<td>178372</td>
<td>74.4</td>
<td>72.2</td>
</tr>
<tr>
<td>15-24</td>
<td>227577</td>
<td>216971</td>
<td>60.3</td>
<td>67.1</td>
</tr>
<tr>
<td>25-44</td>
<td>759341</td>
<td>720325</td>
<td>72.1</td>
<td>61.5</td>
</tr>
<tr>
<td>45-85</td>
<td>587805</td>
<td>594328</td>
<td>66.3</td>
<td>56.3</td>
</tr>
<tr>
<td>&gt;65</td>
<td>337782</td>
<td>505223</td>
<td>51.8</td>
<td>41.9</td>
</tr>
<tr>
<td>Tot</td>
<td>2166637</td>
<td>2281205</td>
<td>68.0</td>
<td>57.3</td>
</tr>
</tbody>
</table>

Table 1: People living in Veneto on 1st of January 2003 divided in age and sex groups (data obtained from ISTAT, Census 2001 updated to 2003). Fraction of people who eats salami at least once a week divided in age and sex groups (data based on "Aspetti della vita quotidiana" survey on family from ISTAT, 2003)

Results

563 samples were collected at retails (315 raw sausage samples and 248 ripened sausage samples) and 53 were found positive to Salmonella, with a frequency of 11.4% (CI [8.85;14.77]) for raw sausages and 6.8% (CI [4.72;10.07]) for ripened sausages. Results of the enumeration using most probable number (MPN) method are shown in Figure 2.

Using the previous results as input for the model, the risk of salmonellosis from the consumption of a single portion of sausages was estimated to vary from 0 to 8.24x10^3 with a mean of 1.79x10^3 for raw sausages and from 0 to 1.79x10^3 with a mean of 2.59x10^5 for ripened sausages.

The number of human cases of salmonellosis associated with the consumption of both raw and ripened sausages was estimated to be approximately 18 case out of 100,000 servings.

The expected number of cases associated with the consumption of Salmonella contaminated sausages was estimated to be approximately 229 per year (95% confidence interval: from 176 to 262 cases).
The simulation also showed that especially 25-44 aged men and 25-44 aged women were at higher risk than other groups (Fig. 4).

Fig. 4: Age distribution of estimated human cases of salmonellosis associated with the consumption of sausages divided in sex groups in Veneto.

Discussion and conclusions

The presented model provides us with some good indications of how relevant is the consumption of pork sausages in relation to the risk of salmonellosis. However it should be kept in mind that the model needs to be further developed by taking into account the exclusion of several steps of the "farm-to-fork" approach as well as the uncertainty about some of the parameters. Furthermore, some of the assumptions made in the development of the model need to be discussed.

In particular, due to the lack of data on infective dose of Salmonella, we chose to use the Beta Poisson model proposed by Rose and Gerba (1991). The probability of illness was assumed by reducing the report attack rate in feeding studies on human volunteers (McCullough and Eisele, 1957).

In the presented model, collected data as well as published data were used to establish input settings.

Concerning the consumption data, we referred to ISTAT survey on family in which the frequencies of generic salami consumption are registered.

References

