THE ASSOCIATIONS BETWEEN HERD CHARACTERISTICS AND SALMONELLA IN
SLAUGHTER AGE PIGS.

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Many factors have the potential to result in exposure of pigs to Salmonella and/or to
increase the potential shedding at the time of slaughter. Observation of selected production
systems has suggested that control of Salmonella may not occur using common disease
management strategies, such as batch pig flow, as do many other diseases.\(^1\) A rational
approach to Salmonella reduction would be to rank risk factors, to aid in selecting. We
designed this study to assess risk factors of Salmonella status at slaughter.

Objectives

- Estimate the herd-level prevalence (percent of herds positive for the pathogen) and
  pig-level prevalence among slaughter weight pigs for \textit{Salmonella spp.}
- Estimate the importance of risk factors for Salmonella positive status of caudal
  mesenteric lymph nodes

METHODS AND MATERIALS

We collected data from 70 farms over the two years of the study. Farms were solicited if they
met the following criteria: 1) participation in a slaughter monitoring program (the PigMON\(^\circ\) system),
2) slaughtered pigs at a major upper Midwest USA processing plant, 3) were within
150 mile radius of the slaughter plant, and 4) agreed to participate.

From this pool, 70 herds were selected, with a maximum of one herd selected per
week. We individually identified fifteen pigs from each herd and collected the following
samples: serum and rectal contents at the farm (within 48 hours prior to shipment), and cecal
contents and caudal mesenteric lymph nodes at slaughter. All samples were individually
cultured, maintaining pig and farm identity. Cultural were enriched and plated on selective
media using conventional methods.\(^2\) An extensive survey of herd characteristics was
developed and carried out by personal interview for each farm.

We categorized herds into high and low prevalence categories based on the prevalence
of Salmonella for each individual tissue sampled. Herds with prevalence higher than the
mean of all herds (Table 2) were categorized as "high" prevalence. We then compared the
herd factors with the odds of being classified "high" prevalence. Since the number of farms
was limited, we did not examine the effects of interaction among potential risk factors. We

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list only those results with an odds ratio greater than two or less than one-half. Finally, only those associations that have at least five farms in each factor category are presented, to reduce the possibility of spurious association.

RESULTS

A total of 4,124 samples was processed from 1057 pigs (Table 1). Of these, 422 samples were positive from 294 pigs and 55 farms. Prevalence varied by sample as follows: cecal contents, 17.4%, caudal mesenteric lymph nodes, 13.9%, feces collect at the farm, 5.4%, and feces (rectal contents) collected at the slaughter plant, 4.0%. The within herd prevalence distribution suggested that a small number of farms had high prevalence of isolation (table 2). Fifty-seven farms were farrow-to-finish systems, nine did not farrow, and four did not respond. Twenty-one farms each had a single site for all stages of production. Farms produced pigs in differing numbers of post-weaning stages as follows: single stage, five farms; two-stage, 25 farms, three-stage, 30 farms, more than three-stage, two farms, unknown, eight farms.

We categorized survey responses. Categories included farm characteristics (single/multiple sites, size of farm), farm management, and transport / lairage characteristics. Continuous variables were categorized into large/small based on their mean value. Nineteen of 70 farms were categorized as "high" prevalence of Salmonella in mesenteric lymph nodes.

The factors associated with an altered risk of "high" Salmonella prevalence were grouped by their associate p-values into three categories: p<.1, .1<p<.2, and .2<p<.3. The factors identified were as follows (odds ratio shown in parentheses):

- p<.1: sold as the last marketing group from a batch (7.9, versus first pigs marketed) shipment to slaughter through a collection station (.2, versus direct shipment)
- p<.2: contract production (5.6, growing pigs on contracted farms vs. farrow-to-market) longer time (> 19.5 hours) for shipment and lairage (.4) use of wood in gating (.3)
- p<.3: no sanitation of slaughter transport truck (.4, vs. any sanitation method) the use of fans-only for ventilation (2.1) animal fat in the diet (.3) wet feeding (.3) weaning age less than 19 days (2.1)

Categorical factors with at least five farms in each category, but with odds ratios of <2 and >.5 included herd size ( inventoried breeding females), outside source of growing pigs, batch pig

<table>
<thead>
<tr>
<th>tissue / sample</th>
<th>farms</th>
<th>pigs</th>
<th>mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>cecal contents</td>
<td>70</td>
<td>1039</td>
<td>14.8</td>
</tr>
<tr>
<td>mesenteric lymph nodes</td>
<td>70</td>
<td>1038</td>
<td>14.8</td>
</tr>
<tr>
<td>feces at the farm</td>
<td>68</td>
<td>1057</td>
<td>15.5</td>
</tr>
<tr>
<td>feces at the plant</td>
<td>67</td>
<td>990</td>
<td>14.8</td>
</tr>
<tr>
<td>totals</td>
<td>70</td>
<td>4124</td>
<td>58.9</td>
</tr>
</tbody>
</table>

Table 2. Herd- prevalence of Salmonella culture by tissue by within-herd prevalence category.

<table>
<thead>
<tr>
<th>sample</th>
<th>percent positive</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt;0%</td>
</tr>
<tr>
<td>feces-farm</td>
<td>17.6%</td>
</tr>
<tr>
<td>feces-plant</td>
<td>23.9%</td>
</tr>
<tr>
<td>cecal content</td>
<td>61.4%</td>
</tr>
<tr>
<td>lymph node</td>
<td>47.1%</td>
</tr>
</tbody>
</table>


flow, ownership or use of truck for more than one herd for shipment to slaughter, gross contamination of truck, diagnosis of Salmonella in the past six months, age at slaughter, underweight vs. normal marketing, multiple site production, flooring type, and observation of rodents by herd worker.

DISCUSSION

The factors identified represent potential risk factors for analysis in future intervention studies and candidate critical control points for the development of HACCP or BMP protocols. Of particular interest are those factors that can practically be manipulated in commercial production, including the feeding of wet feed, methods of handling pigs at slaughter, and weaning age. The last pigs marketed out a group are likely to be slower growing pigs, and these are at increased risk. This seems to suggest that these pigs are more susceptible to infection or shedding, or that infection causes decreased growth rate. Longer transit time and indirect method of shipment (through a collection station) were both associated with a decreased risk of infection. This is in contrast with other work that has suggested that longer transit time and movement through a public auction yard may be associated with increased risk in sows. However, transit/lairage times were limited among farms in this study, as the average time was less than 24 hours. It may be that very short times may increase the risk of Salmonella in lymph nodes.

Several factors commonly expected to reduce occurrence of enteric disease were not associated with reduced Salmonella, including batch pig flow, sanitation of truck carrying pigs to market, underweight pigs, and multi-site production. Thus, reduction of Salmonella may require new models of disease reduction. Size of farms had no association, suggesting that the techniques adopted by newer, larger farms have little effect on risk. Limited sample size has restricted the interpretation of this data. No effects were documented at the commonly accepted p-value of <.05. Further, we were not able to test for interactions among potential risk factors. Finally, in this analysis we made multiple comparisons, elevating the study-wide error rate, and increasing the potential for incorrectly identifying risk factors. The clarification of risk factors will require larger scale study, and/or prospective intervention studies to document the effect.

REFERENCES
1. Davies, PR, Morrow WEM, Jones FT, Deen J, Fedorka-Cray PJ and Harris IT. Accepted. Epidemiology and Infection.