Research Note

Relationship between Listeria monocytogenes and Listeria spp. in Seafood Processing Plants

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ABSTRACT

The objective of this study was to evaluate the relationship between prevalence of Listeria monocytogenes as an outcome and Listeria spp. as an explanatory variable by food products, food contact surfaces, and nonfood contact surfaces in seafood processing plants by using peer-reviewed published data. Nine sets of prevalence data of L. monocytogenes and Listeria spp. were collected from published studies and used for the analyses. Based on our analysis, the relationship between L. monocytogenes prevalence and Listeria spp. prevalence in food products (incoming raw materials and finish products) was significant (P = 0.04) with (low) \( R^2 = 0.36 \). Furthermore, Listeria spp. were not a good indicator for L. monocytogenes when testing food contact surfaces (\( R^2 = 0.10 \)). Listeria spp. were a good indicator for L. monocytogenes only on nonfood contact surfaces (\( R^2 = 0.90 \)). On the other hand, the presence of Listeria spp. on food contact surfaces (\( R^2 = 0.002 \)) and nonfood contact surfaces (\( R^2 = 0.03 \)) was not a good indicator for L. monocytogenes presence in food products. In general, prevalence of Listeria spp. does not seem to be a good indicator for L. monocytogenes prevalence in seafood processing plants.

It is estimated that Listeria monocytogenes causes 1,591 cases of listeriosis annually in the United States, with 1,455 hospitalizations and 255 deaths (14). A wide range of food commodities have been linked to cases of listeriosis including seafood such as cold- and hot-smoked salmon, gravad salmon, shrimp, fermented fish, and fish salads (2, 3, 12).

In a L. monocytogenes risk assessment model by the U.S. Department of Agriculture, the U.S. Food and Drug Administration, and the Centers for Disease Control and Prevention for ready-to-eat food, smoked seafood was ranked the sixth riskiest food associated with listeriosis (1). L. monocytogenes and Listeria spp. have been frequently isolated from seafood processing plants, where some strains can persist for a long time, e.g., months or years (13, 19, 21). A number of studies have reported that the primary source of L. monocytogenes contamination in seafood products was the contaminated processing environment (food contact surfaces and/or noncontact surfaces) (4, 8, 15, 18, 21). However, other studies note that incoming raw food materials appear to be the primary source (5, 13). As part of the hazard analysis critical control point (HACCP) program at seafood processing plants, environmental and food testing for presumptive L. monocytogenes and its potential indicators (i.e., Listeria spp.) are performed. Despite the widespread practice of using Listeria spp. as an indicator for the presence of L. monocytogenes, it is not clear whether Listeria spp. reliably serve this role in seafood processing plants.

This research was undertaken to systematically examine published data on the prevalences of L. monocytogenes and Listeria spp. in seafood processing plants and evaluate the relationship between prevalence of Listeria spp. and L. monocytogenes in food products, food contact and noncontact surfaces.

MATERIALS AND METHODS

Data collection. Nine different sets of prevalence (i.e., percentage) data were collected from peer-reviewed published studies (4–7, 9–11, 13, 15). A data set was used if the study met two criteria: (i) estimates (prevalence) of both Listeria spp. and L. monocytogenes are provided, and (ii) the study was conducted in a seafood processing plant. A seafood processing plant is defined here as a plant that process salmon, crawfish, catfish, or smoked fish. The samples collected in these published studies were tested for both L. monocytogenes and other Listeria spp. Descriptions of the nine data sets are as follows.

Data set I: Data on the percentage of samples positive and total number of samples collected for Listeria species and L. monocytogenes from four smoked fish plants were collected by Thimothe et al. (15). This set contained data on the occurrence of Listeria spp. and L. monocytogenes from food including raw fish and finish fish products, food contact surfaces, and nonfood contact surfaces including environmental and employee contact surfaces. Listeria spp. included L. monocytogenes in this data set.

Data set II: Data on the percentage of samples positive and total number of samples collected for Listeria spp. and L. monocytogenes from three catfish processing plants were collected...
Table 1. Mean and 95% confidence intervals of Listeria spp. and Listeria monocytogenes prevalence data by food, food contact surfaces, and nonfood contact surfaces.

<table>
<thead>
<tr>
<th>Source</th>
<th>Mean</th>
<th>95% confidence interval</th>
<th>Mean</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td>25.6</td>
<td>17.6-33.6</td>
<td>20.0</td>
<td>12.2-27.8</td>
</tr>
<tr>
<td>Food contact surfaces</td>
<td>18.5</td>
<td>13.3-23.6</td>
<td>11.1</td>
<td>6.7-15.4</td>
</tr>
<tr>
<td>Nonfood contact surfaces</td>
<td>30.1</td>
<td>20.7-39.6</td>
<td>18.9</td>
<td>9.8-28.0</td>
</tr>
</tbody>
</table>

*Number of the overall observations for food, food contact surfaces, and nonfood contact surfaces were 37, 45, and 32, respectively.

Data set VIII: Data on the percentage of samples positive and total number of samples collected for Listeria spp. and L. monocytogenes from six smoked fish processing plant were collected by Eklund et al. (6). This set contained data on the occurrence of one Listeria spp. (i.e., innocua) and L. monocytogenes from food (e.g., finished products).

Data set IX: Data on the percentage of samples positive and total number of samples collected for Listeria spp. and L. monocytogenes from one smoked fish processing plant were collected by Rorvik et al. (13). This set contained data on the occurrence of Listeria spp. and L. monocytogenes from food (e.g., finished products), food contact surfaces (e.g., smoked oven), and nonfood contact surfaces (e.g., sinks). Listeria spp. included L. monocytogenes in this data set.

**Results and Discussion**

The number of observations for both Listeria spp. and L. monocytogenes occurrence in food, food contact surfaces, and nonfood contact surfaces of seafood processing plants from all the studies was 37, 45, and 32, respectively. The weighted mean and 95% confidence intervals of Listeria spp. and L. monocytogenes prevalence data by food, food contact surfaces, and nonfood contact surfaces are shown in Table 1. The observed data and the fitted linear regression line for Listeria spp. and L. monocytogenes prevalence data in food, food contact surfaces, and nonfood contact surfaces are shown in Figure 1.

The relationship between L. monocytogenes prevalence and Listeria spp. prevalence in food products was significant ($P = 0.04$), with $R^2 = 0.36$ (Fig. 1B). Although the linear regression relationship is significant ($P = 0.04$) between the outcome (i.e., L. monocytogenes) and the explanatory variable (i.e., Listeria spp. prevalence), the $R^2 (0.36)$ suggests that Listeria spp. are not a reliable predictor for the presence of L. monocytogenes in raw and ready-to-eat foods from the seafood processing plants studied here. The low $R^2$ indicates that possibly other factors, not
included in the regression analysis, have an influence on \textit{L. monocytogenes} prevalence.

The relationship between \textit{L. monocytogenes} prevalence and \textit{Listeria} spp. prevalence on food contact surfaces was not significant ($P = 0.23$), with (low) $R^2 = 0.10$ (Fig. 1A).

This suggests that the presence of \textit{Listeria} spp. on food contact surfaces is not a good predictor for the presence of \textit{L. monocytogenes} on food contact surfaces in seafood processing plants. Conversely, the relationship between \textit{L. monocytogenes} prevalence and \textit{Listeria} spp. prevalence on nonfood contact surfaces was quite significant ($P = 0.01$), with $R^2 = 0.90$ (Fig. 1C), and this suggests that \textit{Listeria} spp. are a good predictor of \textit{L. monocytogenes} presence on nonfood contact surfaces in seafood processing plants. This is in agreement with data from a study by Williams et al. (20), who surveyed six ready-to-eat meat processing plants. Those authors reported that the presence of \textit{L. monocytogenes} and other \textit{Listeria} spp. correlated well (in most of the plants) in samples collected from nonfood contact surfaces.

The relationship between \textit{L. monocytogenes} prevalence in food products and \textit{Listeria} spp. prevalence on food contact surfaces was not significant ($P = 0.96$), with $R^2 = 0.002$ (Fig. 2A). Likewise, the relationship between \textit{L. monocytogenes} prevalence in food products and \textit{Listeria} spp. prevalence on nonfood contact surfaces was not significant ($P = 0.54$), with $R^2 = 0.03$ (Fig. 2B). This suggests that relying on the presence of \textit{Listeria} spp. on food contact and noncontact surfaces as a predictor for \textit{L. monocytogenes} in food products (at least in the seafood processing plants studied here) is not warranted. This is in general disagreement with U.S. Department of Agriculture, Food Safety and Inspection Service (17) and Tompkin (16), who indicate that \textit{Listeria} spp. in the environment were a reliable predictor (i.e., indicator) of \textit{L. monocytogenes} in the food products in ready-to-eat meat processing plants.

Control of \textit{L. monocytogenes} contamination in seafood processing plants should be part of any food safety or HACCP program. Many food processing plants (including nonseafood processing plants) choose to test for \textit{Listeria} spp. as indicators for the presence of \textit{L. monocytogenes} (16). However, our analysis shows that (at least for the seafood processing plants that were part of our analysis), \textit{Listeria} spp. were not a reliable indicator for \textit{L. monocytogenes} on food contact surfaces. The prevalence of \textit{Listeria} spp. in
food was not highly correlated ($R^2 = 0.36$) with the prevalence of *L. monocytogenes* in food, although the relationship was statistically significant ($P = 0.04$). *Listeria* spp. did appear to be a reliable indicator ($R^2 = 0.90$) for *L. monocytogenes* on nonfood contact surfaces. Furthermore, our analysis has revealed that prevalence of *Listeria* spp. on food or nonfood contact surfaces were not a good predictor for the prevalence of *L. monocytogenes* in food products.

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**REFERENCES**


