Listeria monocytogenes: An emerging foodborne pathogen in Ghana?


Presented at the University of Ghana's College of Health Sciences annual scientific conference on the increasing burden of non-communicable diseases in Ghana

Accra, Ghana
21-23 September 2011
INTRODUCTION
Foodborne pathogens

• Foodborne pathogens are disease-causing microorganisms transmitted through food.

• Traditionally includes such species of the genera *Salmonella*, *Shigella*, *Escherichia* (Enterotoxigenic *E. coli*), *Campylobacter*, *Clostridium*, *Staphylococcus*, *Streptococcus* (beta type), *Brucella* and *Mycobacterium*. 
Emerging foodborne pathogens

• Over the last 20-25 years, pathogenic microorganisms have been newly described or have been associated with foodborne outbreaks

• These are pathogens which
  – have increased in prevalence in recent decades or are likely to do so in the near future
  – hitherto had not been detected in foods in a given area
  – hitherto had not been implicated in any foodborne illness
  – have been recently detected in foods and/or implicated in foodborne disease outbreaks in a given area
Reasons for emergence

• Increasing preference for ‘natural’ or ‘fresh’ foods

• Complex food supply chains with multi-stakeholder participation and increase in potential points of contamination

• Trends towards global sourcing of raw materials in food production

• Increasing international travel/migration

• Advancements in detection and identification of pathogens

• Better reporting and diagnosis of foodborne illnesses
Examples of emerging foodborne pathogens

- **Viruses**
  - Hepatitis A and E
  - Norovirus
  - Avian influenza virus (H5N1)

- **Parasites**
  - *Cryptosporidium parvum*
  - *Cyclospora cayetanensis*
  - *Anisakis* spp.
Examples of emerging food-borne pathogens

Bacteria

- *Campylobacter jejuni*
- *Mycobacterium paratuberculosis*
- *Salmonella* serotypes *enteritidis* and *typhimurium DT104*
- *Yersinia enterocolitica*
- *Listeria monocytogenes*
**Listeria monocytogenes**

- *L. monocytogenes* is a non-spore forming pathogenic bacterium that causes a highly fatal disease called listeriosis.

- It is considered the leading cause of death among foodborne bacterial pathogens, with a fatality rate of 20-30% and up to 75% in highly immunocompromised individuals.

### Table 1: Fatality of *L. monocytogenes* infection (CDC 2000)

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Illnesses</th>
<th>Deaths</th>
<th>% Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Campylobacter</em> spp.</td>
<td>10,539</td>
<td>99</td>
<td>0.95</td>
</tr>
<tr>
<td><em>Salmonella</em> non-typhoidal</td>
<td>15,608</td>
<td>553</td>
<td>3.54</td>
</tr>
<tr>
<td><em>L. monocytogenes</em></td>
<td>2,298</td>
<td>499</td>
<td>21.71</td>
</tr>
</tbody>
</table>

Department of Nutrition and Food Science, Univ. of Ghana
Table 2: Fatalities of some incidences of listeriosis

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Food</th>
<th>Illnesses</th>
<th>Deaths</th>
<th>%Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finland</td>
<td>1998</td>
<td>Butter</td>
<td>25</td>
<td>24</td>
<td>96</td>
</tr>
<tr>
<td>France</td>
<td>2000</td>
<td>Pork meat</td>
<td>32</td>
<td>31</td>
<td>96</td>
</tr>
<tr>
<td>USA</td>
<td>2000</td>
<td>Turkey</td>
<td>30</td>
<td>7</td>
<td>23</td>
</tr>
<tr>
<td>USA</td>
<td>2002</td>
<td>Turkey</td>
<td>54</td>
<td>11</td>
<td>20</td>
</tr>
<tr>
<td>Switzerland</td>
<td>2005</td>
<td>Cheese</td>
<td>11</td>
<td>2</td>
<td>18</td>
</tr>
<tr>
<td>Canada</td>
<td>2008</td>
<td>Red meat</td>
<td>53</td>
<td>20</td>
<td>38</td>
</tr>
</tbody>
</table>
Disease symptoms

- Incubation period of human listeriosis is typically **2-3 weeks**, and up to **three months**
- Systemic transmission of pathogen
- Growth of pathogen in phagocytes
Disease symptoms

Non-invasive infection

– gastroenteritis characterized by chills, headache, diarrhoea, abdominal cramps, nausea, vomiting, fatigue
Disease symptoms

Invasive infection

Several clinical manifestations
– meningoencephalitis
– septicemia and abortions
– premature birth
– spontaneous abortions
– still births
Some clinical manifestations of listeriosis
Routes of transmission

• Contaminated food is the principal route of infection in humans

– estimated to be the source in as high as 99% of listeriosis cases
Foods frequently contaminated

• Milk and milk products
• Soft cheese
• Processed meats, red meat
• Vacuum packaged beef and poultry products
• Lettuce
• Coleslaw
• Fried rice
• Smoked fish
• Salted fish
Occurrence of listeriosis in Ghana

• Human listeriosis is not documented in Ghana. However, the occurrence of the illness among herds of sheep has been reported (Osei-Somuah et al. 2000)

• Symptoms suggestive of *L. monocytogenes* infection are also recorded in disease reporting in health facilities
  – Prevalence of meningitis
    • In 2009, >80% of disease cases reported in the district covering Ashiaman where raw milk consumption is high were meningitis
    • In 2008, 73% of monthly disease cases reported in the same district were meningitis
  – Prevalence of spontaneous abortions (Table 1)
Table 1: Abortions recorded at Tema General Hospital in 2008

<table>
<thead>
<tr>
<th>Month</th>
<th>Spontaneous</th>
<th>Induced</th>
<th>D&amp;Cs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>37</td>
<td>3</td>
<td>40</td>
</tr>
<tr>
<td>Feb</td>
<td>33</td>
<td>2</td>
<td>35</td>
</tr>
<tr>
<td>Mar</td>
<td>32</td>
<td>2</td>
<td>34</td>
</tr>
<tr>
<td>Apr</td>
<td>29</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>May</td>
<td>47</td>
<td>5</td>
<td>52</td>
</tr>
<tr>
<td>Jun</td>
<td>63</td>
<td>2</td>
<td>65</td>
</tr>
<tr>
<td>Jul</td>
<td>80</td>
<td>1</td>
<td>81</td>
</tr>
<tr>
<td>Aug</td>
<td>51</td>
<td>3</td>
<td>54</td>
</tr>
<tr>
<td>Sep</td>
<td>55</td>
<td>3</td>
<td>58</td>
</tr>
<tr>
<td>Oct</td>
<td>48</td>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td>Nov</td>
<td>38</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>Dec</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
L. monocytogenes risk assessment studies in Ghana

• Studies to determine the risk of consuming foods from the informal markets in Ghana contaminated with *L. monocytogenes* are ongoing at the Department of Nutrition and Food Science, University of Ghana

• Food commodities covered/being covered are:
  – Raw milk on informal markets (*completed*)
  – Coleslaw in street foods and restaurants (*completed*)
  – Traditionally processed fish on informal markets (*completed*)
  – Fresh cut fruits (*ongoing*)
  – Imported frozen meat (*ongoing*)
Main objectives of studies

1. To determine the presence and concentration of *Listeria monocytogenes* in the products

2. To determine the exposure of consumers to the pathogen through consumption of the products

3. To determine the risk of infection following ingestion of the pathogen
Methodology
Summary

- Health and consumer surveys
- Commodity sampling and laboratory analysis
- Exposure assessments
- Dose-response assessments
- Risk estimations
Health and consumer surveys

• Commodity value chains are studied to obtain inputs for risk assessment using
  – Structured questionnaires
  – Focus group discussions
  – Participatory rural appraisals
Primary Enrichment
LEB, 37°C, 24h

Secondary Enrichment
Fraser, 37°C, 24-48h

Plating on Oxford or Chromagar, 37°C, 24-28h
Exposure assessment

- **Prevalence** was determined as the percentage of samples in which the organism was isolated.

- **Concentration** was expressed as the colony forming units of *L. monocytogenes* per gram or ml of product.

- Likely numbers of *L. monocytogenes* ingested,

  \[ N = Q \times S \]

  - **Q**: quantity/volume often consumed at an instance
  - **C**: concentration of *L. monocytogenes* in product
Dose-response

- Weibull-Gamma model was used

\[ P_{\text{ill}} = 1 - [1 + (N^b)/\beta ]^{-\alpha} \]

- \( P_{\text{ill}} \) = probability of illness
- \( N \) = dose of \( L. \) monocytogenes (i.e. likely number ingested)
- \( \alpha, \beta, b \) = model parameters
- \( \alpha = 0.25, b = 2.14 \) (Bemrah et al., 1998)
- \( \beta = 10^{10.98} \) for high-risk population
- \( \beta = 10^{15.26} \) for low risk population (Bemrah et al., 1998)
Results and discussion
Key findings

1. *L. monocytogenes* was widely detected in the different food commodity samples analyzed.

2. There are some risks of ingesting *L. monocytogenes* through processed foods on informal markets. However, the risks are low.

3. Sanitary conditions of processing and handling are unsatisfactory and are the potential sources of contaminations.

4. Improving hygienic handling of processed foods and appropriately managing of the critical control points in these processes could eliminate these risks.
Table 1: Prevalence of *Listeria/L. monocytogenes* in milk samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; Batch</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; Batch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>Listeria</em> sp.</td>
<td><em>L. monocytogenes</em></td>
</tr>
<tr>
<td>Production</td>
<td>84.2%</td>
<td>47.4%</td>
</tr>
<tr>
<td>Retailed</td>
<td>100.0%</td>
<td>84.2%</td>
</tr>
<tr>
<td>Boiled</td>
<td>21.1%</td>
<td>21.1%</td>
</tr>
<tr>
<td>Fermented</td>
<td>73.7%</td>
<td>52.6%</td>
</tr>
</tbody>
</table>
Table 2: Likelihood of illness from ingesting milk contaminated with *L. monocytogenes*

<table>
<thead>
<tr>
<th>Product</th>
<th>Mean probability of illness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk at production</td>
<td>$1.64 \times 10^{-9}$</td>
</tr>
<tr>
<td>Milk at retail</td>
<td>$1.02 \times 10^{-8}$</td>
</tr>
<tr>
<td>Boiled milk</td>
<td>$1.30 \times 10^{-8}$</td>
</tr>
<tr>
<td>Fermented milk</td>
<td>$5.45 \times 10^{-7}$</td>
</tr>
</tbody>
</table>
# Coleslaw

Table 3: Prevalence of *L. monocytogenes* in coleslaw

<table>
<thead>
<tr>
<th>Samples</th>
<th>Number</th>
<th><em>Listeria</em> colonies tested</th>
<th><em>L. monocytogenes</em> confirmed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabbage</td>
<td>23</td>
<td>115</td>
<td>96 (85.3%)</td>
</tr>
<tr>
<td>Coleslaw</td>
<td>58</td>
<td>290</td>
<td>227 (78.3%)</td>
</tr>
</tbody>
</table>
Fig. 1: Load of *L. monocytogenes* in coleslaw samples at consumption point.
## Fish

Table 1: Average prevalence of *Listeria monocytogenes* in traditionally processed fish purchased from some informal markets in Accra and Tema

<table>
<thead>
<tr>
<th>Product</th>
<th>Number of samples purchased</th>
<th>Number of samples positive for <em>L. monocytogenes</em></th>
<th>Prevalence of <em>L. monocytogenes</em> (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoked tuna</td>
<td>15</td>
<td>12</td>
<td>80</td>
</tr>
<tr>
<td>Smoked mackerel</td>
<td>15</td>
<td>14</td>
<td>93</td>
</tr>
<tr>
<td>Smoked herrings</td>
<td>15</td>
<td>10</td>
<td>67</td>
</tr>
<tr>
<td>Sundried sardines</td>
<td>15</td>
<td>9</td>
<td>60</td>
</tr>
<tr>
<td>Koobi</td>
<td>15</td>
<td>6</td>
<td>40</td>
</tr>
<tr>
<td>Kako</td>
<td>15</td>
<td>8</td>
<td>53</td>
</tr>
<tr>
<td>Mononi</td>
<td>15</td>
<td>8</td>
<td>53</td>
</tr>
</tbody>
</table>
Fig. 1: Average counts of *L. monocytogenes* in fish samples

KA-kako (salted)  KO-koobi (salted)  MO-momoni (salted)
TU-tuna  MA-Mackerel  HR-herrings  DR-dried fish
Fish contaminated with *Lm* on informal markets

- **No**
  - Ingestion not likely

- **Yes**
  - Fish eaten as is (without heating)
    - **No**
      - Ingestion not likely
    - **Yes**
      - *Lm* survives in fish during cooking
        - **No**
          - Ingestion not likely
        - **Yes**
          - Risk of ingestion
            - $N = C \times S$

**Fig. 2:** Event tree for risk of ingestion of *Listeria monocytogenes* through consumption of traditionally smoked fish purchased from informal markets

Department of Nutrition and Food Science, Univ. of Ghana
Table 2: Summary of ranges of probability of illness among consumers (without regard to communities) of traditionally processed fish

<table>
<thead>
<tr>
<th>Product</th>
<th>Low Risk Group Respondents</th>
<th>Low Risk Group Elderly</th>
<th>Low Risk Group Children</th>
<th>Low Risk Group Pregnant women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoked Tuna</td>
<td>10^{-4} - 10^{-7}</td>
<td>10^{-1} - 10^{-3}</td>
<td>10^{-1} - 10^{-7}</td>
<td>10^{-1} - 10^{-2}</td>
</tr>
<tr>
<td>Smoked mackerel</td>
<td>10^{-3} - 10^{-6}</td>
<td>10^{-1} - 10^{-2}</td>
<td>10^{-1} - 10^{-2}</td>
<td>10^{-1} - 10^{-2}</td>
</tr>
<tr>
<td>Smoked herrings</td>
<td>10^{-6} - 10^{-8}</td>
<td>10^{-1} - 10^{-2}</td>
<td>10^{-1} - 10^{-3}</td>
<td>10^{-1} - 10^{-5}</td>
</tr>
<tr>
<td>Sundried sardines</td>
<td>10^{-6} - 10^{-7}</td>
<td>10^{-2} - 10^{-3}</td>
<td>*10^{-3}</td>
<td>*10^{-2}</td>
</tr>
<tr>
<td>Kako</td>
<td>10^{-8} - 10^{-11}</td>
<td>10^{-4} - 10^{-6}</td>
<td>-</td>
<td>10^{-4} - 10^{-6}</td>
</tr>
<tr>
<td>Koobi</td>
<td>10^{-7} - 10^{-8}</td>
<td>10^{-3} - 10^{-4}</td>
<td>-</td>
<td>10^{-7} - 10^{-8}</td>
</tr>
<tr>
<td>Momoni</td>
<td>10^{-9} - 10^{-10}</td>
<td>10^{-5} - 10^{-9}</td>
<td>-</td>
<td>10^{-5} - 10^{-9}</td>
</tr>
</tbody>
</table>
Milking and milk handling practices make contamination highly probable.
Processing and handling of fish: Smoked tuna, herrings and mackerel
Processing and handling of sundried fish
Conclusions

*Listeria monocytogenes* were isolated from raw milk, coleslaw and traditionally processed fish on informal markets, although in low concentrations.

The products are potential vehicles for the transmission of *Listeria monocytogenes*.

Symptoms of listeriosis which are also caused by other pathogens are prevalent; however *L. monocytogenes* is not in the list of pathogens of interest in the country.
The “big” questions

1. Is *Listeria monocytogenes* a prevalent foodborne pathogen in Ghana?

2. Could listeriosis be an emerging foodborne disease in Ghana?
Recommendations

- Further studies on the occurrence (prevalence and concentration) of the pathogen in other foods on the Ghanaian (informal) market
- Screening of placental smears for and molecular typing of *L. monocytogenes* to confirm occurrence of listeriosis
- Improvements in the sanitary conditions of traditional food processing
- Optimization of unit operations in traditional food processing, e.g. pasteurization, fermentation and smoking
Thank you