WHAT SHOULD BE DONE TO DECREASE THE INCIDENCE OF HUMAN SALMONELLOSIS IN CANADA?

by

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We accept this thesis as conforming to the required standard

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July 1978
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Date September 14, 1978
The thesis is concerned with what should be done to decrease the incidence of human salmonellosis in Canada. The present high incidence of Salmonella contaminated poultry is reviewed and evidence is given that links Salmonella contaminated poultry carcasses at the retail level to human salmonellosis. The question is raised as to whether control or eradication should be the goal in Canada, and present regulations involving various levels of Governments are examined.

The incidence of Salmonella contaminated poultry in some other countries is reviewed, together with some of the Salmonella control programmes that have been instituted by these countries.

Finally, certain recommendations are made, as to what could be done in Canada to decrease the incidence of human salmonellosis. These recommendations stress the need for further research to develop ways of decreasing the incidence of Salmonella contaminated poultry at the retail level. The colonization of the gut of day-old chickens with the intestinal flora of adult chickens is a method that shows promise. The use of radiation and chlorination of the poultry carcasses would also help to reduce the incidence of carcass contamination.

If Canada is determined to reduce human salmonellosis, then steps must be taken to coordinate the many different branches of both
the Federal and Provincial Governments, and regulations, when promulgated, must be enforced. Caterers and those cooking in their own homes must be educated on correct food handling practices and cooking techniques.

Human salmonellosis will probably never be eradicated, but its present incidence could certainly be reduced.
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INTRODUCTION

A news release by Health and Welfare Canada in November 1975 was titled "Salmonella Problem Emphasized". The main theme of this news release was the growing problem of food-borne Salmonella infections. Early in the New Year (1976) the Department of National Health and Welfare planned to introduce regulations under the Food and Drug Act, in order to bring about a progressive decrease in the incidence of Salmonella-contaminated poultry at the retail level. The objective as stated in 1975 was to reduce the incidence of Salmonella-contaminated poultry at the retail level to 5% by 1980.

Survey reports of Canadian processed poultry from 1970 to 1978 show a definite increase in the percentage of Salmonella-contaminated poultry carcasses during this time period.

TABLE I

<table>
<thead>
<tr>
<th>YEAR</th>
<th>NO. BIRDS OR PACKAGES OF PARTS</th>
<th>PERCENT WITH SALMONELLA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970-71</td>
<td>144</td>
<td>15</td>
</tr>
<tr>
<td>1971-72</td>
<td>132</td>
<td>19</td>
</tr>
<tr>
<td>1972-73</td>
<td>259</td>
<td>20</td>
</tr>
<tr>
<td>1973-74</td>
<td>157</td>
<td>23</td>
</tr>
<tr>
<td>1974-75</td>
<td>45</td>
<td>22</td>
</tr>
<tr>
<td>1975-76</td>
<td>154</td>
<td>36</td>
</tr>
<tr>
<td>1976-77 (11 months)</td>
<td>365</td>
<td>39</td>
</tr>
</tbody>
</table>

HEALTH PROTECTION SURVEYS
Further evidence of the increase in the percentage of Salmonella-contaminated processed poultry, can be shown from other studies. A Japanese study\(^4\) during 1971 and 1972 reported that 17.6% of imported Canadian poultry meats were found to be positive for Salmonella. Duitschaever\(^5\) in a Canadian study done in 1975 on cut-up raw chicken pieces found that 34.8% of the packages were contaminated with Salmonella, and that eleven different serotypes were isolated. In a recent study by Skura\(^6\) 21.5% of chicken carcasses were found to be Salmonella-contaminated. The results of the latest Health Protection Branch study\(^7\) show that about 35% of the processed chicken carcasses that were sampled were Salmonella-contaminated.

**TABLE II**

**SAMPLES OF IMPORTED POULTRY - JAPAN 1971-72**

<table>
<thead>
<tr>
<th>COUNTRY OF ORIGIN</th>
<th>NO. OF TESTED SAMPLES</th>
<th>NO. OF POSITIVE SAMPLES</th>
<th>% CONTAMINATED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. DENMARK</td>
<td>532</td>
<td>20</td>
<td>3.8</td>
</tr>
<tr>
<td>2. HUNGARY</td>
<td>332</td>
<td>119</td>
<td>5.7</td>
</tr>
<tr>
<td>3. CHINA</td>
<td>2,219</td>
<td>207</td>
<td>9.3</td>
</tr>
<tr>
<td>4. U.S.A.</td>
<td>2,728</td>
<td>293</td>
<td>10.7</td>
</tr>
<tr>
<td>5. BULGARIA</td>
<td>340</td>
<td>46</td>
<td>13.5</td>
</tr>
<tr>
<td>6. CANADA</td>
<td>153</td>
<td>27</td>
<td>17.6</td>
</tr>
<tr>
<td>7. NETHERLANDS</td>
<td>137</td>
<td>39</td>
<td>28.5</td>
</tr>
</tbody>
</table>

Adapted from data by Suzuki\(^4\) (1971-72)
As can be seen from Table II Canada was ranked in sixth place in the Japanese study of Salmonella-contaminated carcasses, with a rate more than four times as great as Denmark.

From the information presented in the above mentioned studies it is easy to understand why Health and Welfare Canada were concerned about the problem of Salmonella in processed Canadian poultry. However since the news release in 1975 it would appear that very little has changed, and that unless very drastic measures are taken, the objective of 5% contamination rate by 1980 is not going to be attained. This thesis will deal with possible measures that Canada could take to reduce the high rate of Salmonella-contamination in processed poultry.

Finn reported that according to studies carried out by the Health Protection Branch of Health and Welfare Canada in 1973, 77% of 335 cases of human salmonellosis were caused by contaminated poultry. Handzel stated that "Chickens, turkeys, and other poultry were a consistently fruitful source of Salmonellae and they were responsible for nearly half the common-vehicle epidemics". Both of these studies were done in Canada and the authors were of the opinion that if the incidence of Salmonella-contaminated poultry was decreased then the incidence of human salmonellosis would in turn be reduced.

Below in Table III the ten most frequent Salmonella serotypes isolated from poultry during the years 1969 to 1973 are presented. Also included in this table are the top ten Salmonella serotypes isolated from humans during the same five year period. From the table it can be seen that eight of the top ten isolations of Salmonella
serotypes found in poultry are the same as those found in the top ten serotype isolations found in humans.

### TABLE III

RANKING OF SALMONELLA ISOLATIONS FROM HUMANS AND POULTRY RELATED SOURCES FOR THE YEARS 1969-73

<table>
<thead>
<tr>
<th>POULTRY RELATED</th>
<th>HUMAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. S.typhimurium 643</td>
<td>1. S.typhimurium 8803</td>
</tr>
<tr>
<td>2. S.thompson 316</td>
<td>2. S.enteritidis 2387</td>
</tr>
<tr>
<td>3. S.saint-paul 257</td>
<td>3. S.thompson 2231</td>
</tr>
<tr>
<td>4. S.infantis 245</td>
<td>4. S.saint-paul 1881</td>
</tr>
<tr>
<td>5. S.enteritidis 154</td>
<td>5. S.newport 1646</td>
</tr>
<tr>
<td>6. S.blockley 143</td>
<td>6. S.infantis 1194</td>
</tr>
<tr>
<td>7. S.san-diego 83</td>
<td>7. S.montevideo 1068</td>
</tr>
<tr>
<td>8. S.heidelberg 63</td>
<td>8. S.heidelberg 757</td>
</tr>
<tr>
<td>9. S.montevideo 50</td>
<td>9. S.blockley 742</td>
</tr>
<tr>
<td>10. S.haardt 43</td>
<td>10. S.bareilly 2217</td>
</tr>
</tbody>
</table>

Further evidence that there is a relationship between Salmonella serotypes found in poultry and those found in humans, is demonstrated in Table IV. Although samples from poultry and poultry related environments (hatcheries, broiler houses, etc.) furnished only between 16 to 33% of all isolations from non-human sources in the five year period
1969 to 1973, the serotypes isolated from poultry accounted for between 85 and 89% of all human isolations during that same period.

### TABLE IV
PERCENTAGE OF POULTRY RELATED SALMONELLA ISOLATIONS AND THE PERCENTAGE OF ALL HUMAN ISOLATIONS OF THE SAME SEROTYPES IN CANADA - 1969-73

<table>
<thead>
<tr>
<th>YEAR</th>
<th>PERCENT OF ALL NON-HUMAN ISOLATES THAT CAME FROM POULTRY AND RELATED ENVIRONMENT</th>
<th>PERCENT OF ALL HUMAN ISOLATES THAT WERE SAME SEROTYPES AS THOSE FROM POULTRY AND POULTRY RELATED ENVIRONMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1969</td>
<td>21.4%</td>
<td>85.0</td>
</tr>
<tr>
<td>1970</td>
<td>31.5%</td>
<td>86.1</td>
</tr>
<tr>
<td>1971</td>
<td>22.0%</td>
<td>88.7</td>
</tr>
<tr>
<td>1972</td>
<td>15.9%</td>
<td>89.0</td>
</tr>
<tr>
<td>1973</td>
<td>27.2%</td>
<td>88.2</td>
</tr>
</tbody>
</table>

PIVNICK

From the evidence presented so far, although it is not conclusive, it would appear that poultry is certainly one of the major sources of human salmonellosis in Canada, and it is assumed for the purpose of this thesis that if the Salmonella contamination rates of poultry eaten in Canada were reduced, then the incidence of human salmonellosis would be diminished.

For the sake of completeness and realizing that Salmonellae are found throughout nature, and that man can be infected from many sources
including his own kith and kin, a brief review of the literature is given. Many household pets have been incriminated in human salmonellosis cases, and Salmonellae have been found to occur naturally in dogs, cats, horses, parakeets, pigeons, doves, ducks, wild birds, rats, mice, hamsters, gerbils, rabbits, guinea pigs, fishes, frogs, turtles, lizards, snakes, and tortoises. Salmonellae have also been isolated from monkeys, skunks, racoons, opossums and squirrels. Morse makes the point that direct contact with the feces of an infected pet is a common source of salmonellosis particularly in cases involving young children, and that indirect sources of infection may be contamination of human food by material from infected pets.

Other sources of Salmonellae that can produce human salmonellosis, which need not be directly related to poultry or pets, can be found in the monthly and yearly "Food-borne Outbreak Reports", compiled by Health Protection Branch of Health and Welfare Canada. For example in the year of 1974 there were a number of different foods incriminated such as chocolate, lamb chops, beef, cheese, bacon, ham, hamburger, pepper, and watermelon. In some of these cases the foods concerned were contaminated due to the use of poor hygienic practices during food preparation.

Salmonella organisms are ubiquitous in nature, but there are some well documented cycles that involve humans and animals. Figure 1
and Figure 2 demonstrate two general cycles of infection, and later in the thesis cycles involving poultry and humans will be dealt with in more detail.

**Figure 1 - Salmonellae in Food Cycle of Infection**

- Contaminated Animal Feed and Fertilizer
  - Poultry
  - Pigs (Few Infected on Farm)
  - Cattle
  - Crowded Transport
    - (Many Infected in Lairages, Processing Plants, Abattoirs)
  - Bulk Egg Products
  - Fowl and Meat
  - Milk
  - Made Up Foods
    - Animal Feed
      - Consumed By
        - Man, Domestic Animals, Vermin
          - Cases or Carriers

Bowmer 34
Figure 1 demonstrates the more common pathways that produce salmonellosis in man and animals, with particular emphasis on the food chain.

\[\text{FIGURE 2 - SALMONELLA CONTAMINATION CYCLES}\]

Edel\(^{35}\)

In Figure 2, Edel stresses the environmental factors responsible for the continuing cycle of Salmonella spread. There are many environmental factors involved which are of importance when considering human salmonellosis, and a few of them will now be discussed.

**WATER**

Water can serve as the vehicle of Salmonella infection for both animals and man. A large water-borne epidemic of human salmonellosis occurred in Riverside, California in 1965, associated with contaminated
unchlorinated drinking water. Hundreds of strains of Salmonella have been isolated from the United States Federal River Basin Project, and a variety of serotypes common to both animals and man were identified. Slanetz in a study of 128 samples of sea water collected from eight sampling stations in the United States and Canadian shellfish waters found that nineteen (15%) were positive for Salmonella.

In a report by the Environmental Protection Service, Environment Canada, in 1975, it was found that Salmonellae of various serotypes were shown to be present in raw and treated wastes at three large, well operated poultry processing plants. Vanderpost and Bell in Alberta have demonstrated a potential hazard associated with the discharge of raw or partially-treated, undisinfected packing plant wastes to natural waters which may be used for recreational purposes, and for the watering of domestic animals.

Hibbs reported an outbreak of salmonellosis in humans, and calves, associated with contaminated creek water.

**DRUGS AND THERAPEUTIC AGENTS**

Drugs of animal origin and yeasts have been found contaminated with Salmonellae. During a two year period, 16 (24%) of 76 drugs of animal origin were examined in the United States and 98 lots of such drugs were recalled because of Salmonella-contamination. Yeasts and yeast substances have been documented as a source of salmonellosis and have been associated with human illness. In a two year period in the United States 34 (21%) of 164 samples of yeast and yeast products contained Salmonellae.
VECTORS

Salmonella serotypes have been isolated from flies, cockroaches, fleas, and ticks, but there are no good epidemiological studies available that demonstrate how important these vectors are. Various inanimate objects have been incriminated in Salmonella outbreaks, mostly in hospitals. Garden soil, fertilizers and house plant products have been reported as being contaminated with Salmonella serotypes. Mittermyer in 1969 found that nine out of 100 samples of nutrient material for potting house plants contained Salmonella organisms.

Because of the ubiquitous nature of Salmonella organisms throughout nature, a decision has to be made as to whether efforts should be made to eradicate or control these organisms.

Control has been defined as "the purposeful reduction of specific disease prevalence to relatively low levels of occurrence, though transmission occurs frequently enough to prevent its permanent disappearance." The term eradication literally means "pulling out by the roots", and in any definition of eradication there must be a continued absence of transmission in a specified area. Thus control is more relative and less absolute than eradication.

In order to achieve and maintain the eradication status of a specific disease within a defined area, two conditions are necessary.

1. No transmission of the organism which causes the disease must occur, or if it does, it does no produce the disease.

2. Adequate surveillance must be present to prevent the re-establishment of the disease from carriers, relapsing cases, or imported sources of infection.
Another definition of eradication is "the extinction of the pathogen that causes the infectious disease in question." Thus even if one member of the species survives then eradication has not been accomplished. This definition implies action on a world-wide basis, whereas the first definition was limited to a specified area. So far no human disease has been eradicated on a world-wide basis, although it would appear that smallpox is very close to being eradicated. However diseases have been eradicated in well defined areas, for example smallpox in North and South America, rabies in England, but surveillance must be continued in these countries until world-wide eradication has occurred.

Thus there is an essential difference between the concepts of control and eradication, for once a disease has been totally eradicated on a world-wide basis, the costly burden of control measures would no longer be required. All eradication programmes have many needs in common, the main ones being, political stability, popular support for the programme, good organization with well trained staff at all levels, and adequate funds.

The degree of difficulty involved in an eradication programme will depend on many factors some of which are:

1. Host specificity of the disease causing organism:
   A disease only found in man, and is spread directly by person to person contact, is much easier to eradicate than a disease which is present throughout the animal kingdom.

2. Effective Vaccine:
   If an effective vaccine is available, then eradication will be much easier.
3. Effective forms of Treatment and Prevention:

If there are effective forms of treatment and prevention of carrier states then eradication will be easier.

4. Diagnosis of the Disease:

If the disease is easy to diagnose, either visually, clinically, or by a rapid laboratory test that is specific then this will be useful in eradication.

5. Severity of the Disease:

The severity of the disease will influence the priority attached to its eradication.

Having examined the concept of eradication in general, how can it be applied to salmonellosis. Is the eradication of Salmonellosis a realistic goal in Canada? Since many countries would not consider the eradication of salmonellosis as a health priority, the first definition of eradication will be used in which eradication was defined as the "continued absence of transmission in a specified area".

1. Host specificity of Salmonella:

A few Salmonellae are for all practical purposes host specific (i.e. S. pullorum and S. gallinarum for poultry and S. typhi for man). However most of the 1,700 serotypes are potentially disease producers for man and animals. 51

2. Effective Vaccine:

Due to the many species of Salmonella that can potentially cause disease, there is no one vaccine that is effective. Even the vaccine for S. typhi is only between 70 and 90% effective. 51
3. Effective Forms of Treatment and Prevention of Carriers:

It is recommended that the treatment of most cases of human salmonellosis should be supportive, and that antibiotics tend to prolong the carrier stage. However in severe cases antibiotics should be used. 52

4. Diagnosis of the Disease:

Salmonellosis cannot be diagnosed clinically, with any degree of accuracy. Laboratory confirmation is required. In some mild cases and in carriers the organism may not be present in the specimen of stool being tested, or the organisms may have died.

5. Severity of the Disease:

The non S. typhi and S. paratyphi infections are not usually life-threatening, although Statistics Canada reports show that from the years 1965 to 1975 about 8 people died per year from the results of the disease. Salmonellosis is most severe in the very young or the elderly, or in any age group where there is a pre-existing medical condition which alters the immune response. Salmonella does produce a fair degree of morbidity although most cases do not last longer than one week.

Levy 53 in a study in the early 1970's of an outbreak of food-borne salmonellosis in which about 125 people were affected, estimated that the economic impact was $28,733. The largest portion of the expense was lost salaries. In the above study the illness ranged from mild to moderately severe and lasted an average of five days.
Finn\(^3\) did a benefit-cost analysis for the eradication of Salmonella from all chicken meat produced in Canada. He estimated that such an eradication programme would take ten years and that the total cost would be about $300 million. The benefit he estimated would be $23 million.

Thus the program would cost $12.68 for every $1 benefit. In this study Finn only looked at the costs for the eradication of Salmonella from chickens, and did not look at costs for the eradication of Salmonella from turkeys, cattle, etc.

How many Canadians are infected per year with Salmonella organisms? In Canada there are two National Information systems.

The first system is a physician based notification mechanism whereby clinically diagnosed cases are notified to the Medical Health Officers, and then to the Provincial Epidemiologists. They in turn report to Statistics Canada. This data published by Statistics Canada is then incorporated into the Canadian Diseases Weekly Report, in the form of "Notifiable Diseases Weekly Summary", as well as the Statistics Canada "Annual Report of Notifiable Diseases".

In the second notification mechanism, the ten Provincial Laboratories report their laboratory isolates to the National Enteric Reference Centre (N.E.R.C.) on a weekly and monthly basis. This data is then published in the N.E.R.C. Weekly and Monthly Reports, the L.C.D.C. Newsletter, as well as the C.D.W.R.
Both national information systems are difficult to interpret because of their lack of uniformity of Provincial data notification, and by the various deficiencies with which each system is burdened. For example, North West Territories and the Yukon, are not included in the N.E.R.C. reports, but they are reported to Statistics Canada.

The Federal Advisory Committee on Epidemiology is reviewing the question of Salmonella information systems. See Appendix A for Human Salmonellosis Information Flow Chart. (Bollegma)54

There is ample evidence to support the conclusion that salmonellosis is grossly under-reported. For example during the water-borne outbreak of gastroenteritis caused by serotype typhimurium in Riverside, California in 1965, there were 110 human isolations, and approximately 200 cases of gastroenteritis were known to the health department; but the epidemiologic evidence indicated that there were at least 16,000 cases of gastroenteritis.

Another example occurred in Oxford, Nebraska, where in 1967 there was an outbreak of S. typhimurium gastroenteritis following the consumption of contaminated turkeys. There were five isolations from individuals with clinical disease reported through normal reporting channels; however, during a stool culture survey, 261 isolations were made, 158 from individuals with clinical disease and 103 from asymptomatic carriers. In fact an estimated 2,600 infections occurred as determined by epidemiological investigations, resulting in 1,900 clinically ill individuals and 700 asymptomatic carriers.
Appendix A  (Illustration 1)

Source of Information

The 10 provincial Laboratories
They report the number and types of Salmonella serotypes

National Enteric Reference Centre
L.C.D.C. Ottawa

Responsibility party for information input into the publication

N.E.R.C. Weekly Report
(Human Salmonellosis)

N.E.R.C. Monthly Report
(human and non-human Salmonella isolates)

L.C.D.C. Newsletter

Where data is published
# of copies distributed

N.E.R.C. Weekly Report
(Human Salmonellosis)

C.D.W.R. (Bureau of Epidemiology publication)
(information included every 4 weeks)

C.D.W.R.
(Information as a weekly inclusion)

Annual Report of Notifiable Diseases
(a) Hospital Morbidity
(b) Causes of Death

NOTES:
(1) Inspection triggered at provincial and federal levels: e.g.: (1) Veterinary Public Health Service, Ontario) These do not report into the (II) Field Operations Directorate (federal) notification system

(2) The Central Prov. Labs. generally also send reports to the Prov. Epidemiologists (L. or M.O.H.'s) as well as the physicians. The procedure varies with the provinces.

(3) LEGEND:
+= Do nothing
*= Consumer Affairs, etc.
Ind. case.= Individual Case
▲* Specimens may either not be taken, or the organism was not identified (due to loss in transit, or lack of lab. facilities).
Priv. Lab. = Private lab.
Reg. Lab. = Regional Provincial Lab.
Hosp. Lab. = Hospital lab.
The third example of under-reporting involved eggs contaminated with S. derby, where there would have been fewer than 100 cases reported through normal channels. However as a result of special studies over 1,000 cases were identified by bacterial culture of stool specimens.25

<table>
<thead>
<tr>
<th>PLACE</th>
<th>VEHICLE</th>
<th>CASES REPORTED</th>
<th>CASES BY EPIDEMIOLOGICAL INVESTIGATION</th>
<th>AGENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>CALIFORNIA</td>
<td>WATER</td>
<td>200</td>
<td>16,000</td>
<td>SALMONELLA typhimurium</td>
</tr>
<tr>
<td>NEBRASKA</td>
<td>TURKEY</td>
<td>5</td>
<td>1,900</td>
<td>SALMONELLA typhimurium</td>
</tr>
<tr>
<td>U.S.A - 13 states</td>
<td>EGGS</td>
<td>&lt; 100</td>
<td>&gt; 1,000</td>
<td>SALMONELLA derby</td>
</tr>
</tbody>
</table>

Although the above three examples are from the United States, Pivnick3 when describing the Canadian scene stated "It is probable that there are between 10 and 100 cases of Salmonellosis in humans for every case that is reported, but the unreported cases are not sufficiently serious to receive medical attention or be diagnosed. Nevertheless they must represent a great deal of discomfort, a large number of lost days from school or employment, and a very large loss in dollars to the economy".
From Table VI, it would appear that between 4,000 and 5,000 people a year in Canada are sufficiently ill to require medical attention, and have laboratory investigations performed.

**TABLE VI**

REPORTED HUMAN INFECTIONS BY SALMONELLA IN CANADA

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NO. REPORTED (STAT CAN)</td>
<td>4,176</td>
<td>3,548</td>
<td>4,261</td>
<td>3,910</td>
</tr>
<tr>
<td>NO. REPORTED (N.E.R.C.)</td>
<td>5,140</td>
<td>4,607</td>
<td>5,235</td>
<td>5,054</td>
</tr>
<tr>
<td>NUMBER HOSPITALIZED</td>
<td>1,052</td>
<td>1,028</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVERAGE DAYS IN HOSPITAL</td>
<td>14.3</td>
<td>13.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL DAYS IN HOSPITAL</td>
<td>15,043</td>
<td>13,981</td>
<td>15,000(EST)</td>
<td>15,000(EST)</td>
</tr>
<tr>
<td>ESTIMATED COST FOR HOSPITAL</td>
<td>1,500,000</td>
<td>1,500,000</td>
<td>1,700,000</td>
<td>1,900,000</td>
</tr>
</tbody>
</table>

*Typhii and Paratyphi Excluded*

*Statistics Canada*

*National Enteric Reference Centre*

Finn estimated the expenses resulting from human salmonellosis to be about $8 million per year, expressed in 1976 dollars. A breakdown of this total is as follows:
TABLE VII

COST PER YEAR OF HUMAN SALMONELLOSIS IN CANADA AS ESTIMATED IN 1976

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wages Lost due to Salmonellosis</td>
<td>$4,760,724</td>
</tr>
<tr>
<td>Cost of Hospitalization</td>
<td>$2,000,000</td>
</tr>
<tr>
<td>Value of Lives Lost</td>
<td>$216,000</td>
</tr>
<tr>
<td>Medical Treatment</td>
<td>$1,000,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$7,976,724</strong></td>
</tr>
</tbody>
</table>

Information from Finn

Pivnick although he did not try to estimate the cost of human salmonellosis directly related to chicken sources, as Finn did, instead he tried to estimate the cost of human salmonellosis from all sources. It would appear that Finn's estimate of about $8 million is on the low side, for Pivnick is of the opinion that the percentage of poultry related cases of human salmonellosis is substantial.

Pivnick wrote, "We have estimated the cost to Canada of all human salmonellosis from data and concepts presented by Levy and McIntire, and have arrived at a figure of not less than $25,000,000 and not more than $100,000,000 per year."
The genus Salmonella is within the family enterobacteriaceae and is characterized by its cultural properties, and by its antigens, although neither of these characteristics is wholly exclusive to the genus. The generic term Salmonella was given to these microorganisms by Lignières in 1900 in honour of Dr. D. E. Salmon, a co-discoverer of the microorganism now known as Salmonella cholerae-suis. This generic term was adopted by international agreement on the basis of priority, in accordance with international rules of nomenclature, and has been employed universally since 1933.

Definition of genus Salmonella:

Enterobacteria (fermentative, facultatively anaerobic oxidase-negative Gram-negative rods) that generally are motile, aerogenic, non-lactose fermenting, urease-negative, citrate-utilizing, Voges-Proskauer-negative and KCN-negative (KCN-sensitive).

Laboratory diagnosis of Salmonella:

A diagnosis of Salmonella infection is made by isolation of the organism from blood, feces, urine, or other organs. Isolation from blood or urine is indicative of tissue invasion and ordinarily establishes the diagnosis, but a Salmonella organism isolated from feces, is not necessarily the cause of the individual's illness. Demonstration of a significant rise in antibody titre to the specific organism isolated from the patient is helpful in confirming the diagnosis. However there may not be any change in the antibody titre.
Specimens are initially grown on special culture media, and final identification is based on biochemical reactions and agglutination tests with monospecific antisera.\textsuperscript{58}

**HUMAN SALMONELLOSION**

In any one year only about 150 different serotypes are isolated from humans in Canada. Out of these 150 serotypes about 10 are responsible for over 75\% of human infections and 20 serotypes are incriminated in over 90\% of all human cases of salmonellosis in Canada.\textsuperscript{3}

**Clinical Manifestations\textsuperscript{51}**

Gastroenteritis or "food-poisoning" is by far the most common manifestation of Salmonella infection. The infection varies in severity from mild to extremely severe forms. The onset of symptoms may vary from a few to 72 hours after the ingestion of contaminated food. Nausea, vomiting and diarrhoea are associated with severe abdominal cramps. Fever and prostration may be pronounced. The stools are numerous, watery, and may contain mucus, pus, and blood. Such cases are clinically indistinguishable from bacillary dystentery.

The physical findings are scant, Rose spots and menigismus, are sometimes observed. In about half the patients, the temperature falls to normal within 1 or 2 days, and recovery is uneventful. In others the disease may last for a week or more. Protracted or recurrent diarrhoea is not rare. In very severe infections the patient may become dehydrated and emaciated; a shocklike picture, with cyanosis,
hypothermia, and circulatory collapse, may precede death.

In some cases the gastroenteric type of infection is followed by the enteric fever syndrome, or the septicemic syndrome or by signs of localization, such as meningitis, pneumonia, and osteomyelitis.

Pathogenesis and Pathology of Gastroenteritis:

Salmonella organisms attach themselves to the mucosal epithelial cells and they also penetrate into the deeper submucosal tissues of the gastro-intestinal tract. The multiplication of the organisms at this site is responsible for the inflammation reaction and subsequent disease. The mucosa of the stomach and small intestine is inflamed and edematous.

In spite of the ingestion of the Salmonellae by polymorphonuclear leukocytes and macrophages, the organisms may survive, even in the presence of antibiotic therapy. It is this phenomenon that may be responsible for the persistent carrier state which is found in some patients, especially newborn infants.

Inapparent Infection and the Carrier State:

Of a total of 7,779 positive Salmonella cultures, reported in 1957 by Saphra and Winter, 1,209 (15.5%) were derived from carriers or persons with inapparent infections. Gastroenteritis caused by the same Salmonella type preceded the carrier state in half the instances. In many carriers, the source of infection remains unknown. The carrier state has been estimated to be present in about 0.2% of the
population. The carrier state may clear spontaneously or persist for several years, and the effects of antimicrobial agents in clearing this state has been disappointing.

POULTRY SALMONELLOSIS

Poultry salmonellosis is a collective term used to describe infections with any organism of the Salmonella group other than, S. pullorum (pullorum disease) or S. gallinarum although the most important Salmonella types causing clinical disease in poultry, do not have an association with human food poisoning. These two types of Salmonella organisms are quite different from the many other Salmonella serotypes that infect poultry. An important method of spread of these two types, and particularly of S. pullorum, is the direct result of infection becoming localized in the ovaries of breeding hens. Many of the yolks of the eggs laid by these hens are, as a consequence, also infected.

These two types are seldom recovered from non-avian sources. Another unique feature of these two types is that they cannot colonize the alimentary tract, their presence in the tract always being a consequence of an infection in the tissues. It is this tissue infection that gives rise to the presence of antibodies detectable in routine agglutination tests. It is for these reasons that it is much easier to eradicate S. pullorum and S. gallinarum from poultry. At one time in British Columbia all breeder flocks were blood tested for S. pullorum and S. gallinarum, however this has been discontinued for quite some time, for the British Columbia Poultry Branch consider
British Columbia to be Pullorum-Typhoid free.

All hatchers in British Columbia are routinely sampled by the hatchery inspector. Fluff samples and dead embryos are examined for Salmonella pullorum in the Provincial veterinary laboratory. This type of sampling has replaced the former blood testing on breeder farms. No reactors to S. pullorum have been found since 1964 in British Columbia.

Well over one hundred different Salmonella serotypes have been isolated from poultry. Salmonellosis in young chicks can result in fatality of up to 80% if infected in the first three weeks of life. Chicks that survive may be long term carriers, and adult birds exposed to excretors or contaminated feed, or environment may also become excretors.

In Salmonella infected flocks, the surface of the egg shell frequently becomes contaminated from nest or fecal material. Subsequent penetration of the intact or cracked shell results in multiplication of the bacteria within the egg. Should such infected eggs hatch further dissemination occurs.

It has not been possible to develop a general agglutination test for Salmonella organisms because of the large number of different serotypes involved and because many infected birds do not develop significant antibody levels. An agglutination test for S. typhimurium is now available.

The exact incidence of salmonellosis in poultry is difficult
to ascertain since in many cases the mortality is so low that specimens are not submitted for diagnosis. Although mortality from infection with endemic salmonellae such as S. typhimurium can be high, the exotic and rare serotypes generally speaking result in only low mortality, often about 2 or 3 per cent, but once the environment becomes contaminated an increase in mortality can take place.\textsuperscript{64}

From May to August 1977 Skura\textsuperscript{6} investigated eleven flocks of chicken fryers entering Pancho Poultry Limited, in Surrey, British Columbia. Samples were taken from the first flock killed each day, and thirty birds per flock were examined. These birds were examined at 3 different stages as they passed through the processing plant. At the first stage (before entering the scalding tank) Site A, none of the flocks were completely free of Salmonella (Table VIII).

\begin{table}[h]
\centering
\begin{tabular}{lrr}
\hline
FLOCK & PERCENTAGE OF SAMPLED FLOCK POSITIVE FOR SALMONELLA (AT SITE A) \\
\hline
#1 & 55.6 \\
#2 & 25.0 \\
#3 & 96.2 \\
#4 & 3.5 \\
#5 & 10.7 \\
#6 & 46.2 \\
#7 & 88.5 \\
#8 & 22.2 \\
#9 & 51.7 \\
#10 & 11.5 \\
#11 & 16.0 \\
\hline
\end{tabular}
\caption{Table VIII}
\end{table}

SKURA\textsuperscript{6}

Five flocks were very heavily contaminated with an incidence of Salmonella isolation greater than 50\% of the sampled birds. Heavy
contamination at this point in the poultry processing plant indicated that the exterior (body, feathers and feet) of the birds harboured Salmonella.

Skura also found that flocks heavily contaminated at the first examination point (Site A) also had high incidences of contamination at the other two points in the processing plant. At the third point (Site C) (after the birds had been through the chill tank, see Appendix B for flow chart of the Pancho plant and the sites at which the birds were examined) the average incidence of Salmonella contaminated birds was 21.5 percent, compared with 38.8 percent at the first examination point. In his summary of results Skura stated that "Flocks heavily contaminated at Site A also had high incidences at Sites B and C. Regression equations devised allow prediction of the incidence at one site with knowledge of the incidence at another site."

It is evident from the above study that the incidence of Salmonella found internally and externally on chickens shipped from the farm, significantly influenced the incidence of contaminated carcasses after processing. Thus if contaminated birds enter a processing plant it is very likely that their carcasses at the retail level will also be contaminated. The average percentage of contaminated birds entering the plant was 38.8, and for the same birds leaving the plant it was 21.5 percent. Thus there had been some reduction in the incidence of Salmonella contamination as the birds passed through the plant.
Sites I, II and III represent sites where Skura examined chickens for Salmonella.

APPENDIX B - FLOW DIAGRAM POULTRY PROCESSING

Illustration 2: Sites I, II and III represent sites where Skura examined chickens for Salmonella.

I (Site A)
- Unloading Bay
- Conveyor
- Stunner
- Killer
- Blood Collector
- Couter
- Scalding
- Defeather Unit
- Wash & Finish

II (Site B)
- Neck Removal
- Lung & Kidney Remover
- Head Cutter
- Eviscerator Trough
- Vent Slitter
- Neck Slitter
- Tail Slitter

III (Site C)
- Gizzard Skinner
- Cooling
- Product Chiller
- Grader
- Packaging
- Finished Product
- Shipping

Adapted from McLean-Baird.65
POULTRY AND MAN SALMONELLA CYCLES

As can be seen from the material so far presented a large percentage of processed poultry is contaminated with Salmonella organisms which can potentially lead to human salmonellosis.

Snoeyenbos when describing Salmonella infection at the farm level stated, "information is woefully inadequate to allow accurate assessment of the incidence of Salmonella infection in poultry at the farm level in North America. It is remarkable that national Salmonella control programmes are being considered in both Canada and the United States without a clear picture in either country of the incidence of infection at the farm level."

When examining the Salmonella cycle involving poultry and man, it is assumed that Salmonella from contaminated poultry carcasses are responsible for a large percentage of human salmonellosis cases. But how do poultry flocks become infected?

H. Williams Smith described the methods by which Salmonellae gain entry to poultry flocks, and this is shown in Figure 3.

![Diagram of Salmonella cycle involving poultry and man]

**FIGURE 3 - METHODS WHEREBY SALMONELLAE GAIN ENTRANCE TO POULTRY FLOCKS**
He also went on to describe that once Salmonella organisms had infected some birds, how it then could be further spread within a flock, and this is shown graphically in Figure 4.

FIGURE 4 - DISSEMINATION OF SALMONELLAES FROM BREEDING FLOCKS

McGarr studied the relationship between the parent flock, the hatchery, the progeny broiler flock, the processing plant and the consumer product in Ontario. He found that contaminated carcasses at the consumer outlets were associated with infected broiler chicken flocks which introduced the Salmonella organisms into the processing plant. However the Salmonella infection of the broiler flocks was not associated with salmonellae in their parent breeding flocks or with hatchery contamination. He concluded that broiler chicken flocks in Ontario were commonly infected with salmonellae of undetermined origin.

Hacking investigated the possible sources of introduction of Salmonellae to broiler chicken flocks in Ontario. He found evidence that indicated that day-old chicks, new wood shavings, broiler feed and residual contamination of the buildings from the previous flock were involved in the subsequent infection of the broiler flocks. He also investigated a feed mill, and found that the principle sources of
feed contamination were the animal protein ingredients such as meat meal and feather meal. The pelleting process as used at the particular mill he investigated was inadequate to completely eliminate salmonellae from the feeds, as shown by a 4.3 percent contamination rate found in the finished feeds.

Gordon in earlier studies demonstrated with S. menston that the percentage of carriers in chicks fed artificially-infected feed increased as the numbers of infecting organisms increased, and was almost doubled in those group of chickens whose water supply became contaminated.

It becomes increasingly clear that further studies are required to demonstrate the sources of poultry infection, in order to effectively reduce the number of infected birds entering the processing plant.

Many Salmonella cycle models involving poultry and man have been developed and the one depicted below (Figure 5) demonstrates the major pathways by which Salmonella can infect poultry and man. It is not known which of the various routes is the most important, and it will vary with different environmental, agent and host factors. It is only by examining each part of the cycle and instituting corrective measures throughout the whole cycle that the incidence of infected poultry will be drastically reduced.
Figure 5 - SALMONELLA MODEL

(POULTRY → MAN)

A

Feral Animals
Insects

Contaminated Poultry Feed

B

Contamination of buildings from previous flocks

Poultry

Imported infected day-old chicks

C

Poultry Products (Meat - Eggs)

D

Man → Man
METHODS

Before suggesting methods by which the human salmonellosis rate can be reduced in Canada, it is necessary to find what is being done at the present time to control Salmonella in both humans and animals. Because of the system of Government we have in Canada, both Federal and Provincial agencies are involved and in one or two instances even municipalities.

It had originally been my intent to send out a questionnaire to both the Federal and Provincial agencies involved requesting specific information as to what their departments or ministries were doing in trying to control salmonellosis in humans and animals. This method did not work very well for some questionnaires were not answered at all, some were answered in a very superficial way, and only occasionally did I obtain any really useful information.

When I tried to obtain information from countries other than Canada, it became obvious that countries that were looking at the problem seriously and adopting control programmes could supply me with abundant information of what was being done, whereas countries where very little was being done either didn't reply or their letters were of such a general nature as to be useless. Examples of countries from where I received good information were Sweden and Denmark, and examples of countries that supplied little or no information were New Zealand, and Australia.

In a letter from a Mr. Lancaster who works in the Health of Animals Branch in Ottawa, and who has been involved with poultry diseases for the last 25 years as a veterinarian wrote: "I find it rather
difficult myself to understand who does what in the way of routine screening for Salmonella, and I think your question should be rephrased to, 'How much do they do?'

After the Minister's news release in 1975, the Interdepartmental Salmonella Committee (I.S.C.) was formed to come up with recommendations on how to reduce the incidence of Salmonella on processed poultry carcasses.

I received a copy of the minutes of one of these I.S.C. meetings. This was the 25th meeting of this committee held on July 6th, 1976. The meeting was entirely concerned with "Federal Salmonella Control Programmes" and the minutes were basically an information exchange of what the various Federal Departments were doing. From these minutes it would appear that after 24 meetings of the Interdepartmental Committee, members were still not fully informed as to who was doing what in the area of Salmonella control. I have requested an interim or final report of the deliberations of this committee (I.S.C.) but so far it has not arrived.

Also a committee was formed by the Canadian Poultry Industry, with the title, "The Canadian Poultry Industry Salmonella Committee". This committee consists of six sub-committee chairmen, who are responsible for directing and co-ordinating the efforts within a specific section of the poultry industry. The specific sections are:

(I) Breeder and Hatchery
(II) Feed and Feed Ingredients
(III) Egg and Poultry Meat Production
(IV) Processing and Distribution
(V) Retail and Food Service
(VI) Consumer Awareness
Each of these subcommittees is chaired by some industry leader, in his or her respective area of specialization. The one objective of the Canadian Poultry Industry Salmonella Committee is, through cooperation, to economically reduce the incidence of Salmonella on poultry and poultry products at the retail level in order to meet the proposed regulations.

The first official progress report should have been issued in September 1977, and it is either not completed or is unavailable, for I have requested a copy on two occasions, without success.

Obviously, both the Federal Government, and the Canadian Poultry Industry, are concerned about the Salmonella problem, and are working together to do something about it, but to try and obtain information from either of these two groups at the present time is almost impossible. In fact I have had no information from the Canadian Poultry Industry Salmonellae Committee, and very little from the Interdepartmental Salmonella Committee.

Thus the information given below is certainly not complete, and is liable to be out of date, if new regulations are promulgated by the Canadian Government in the near future.

As far as I could determine the following branches of the Federal Government are involved in some way or another with the Salmonella problem.

1. Bureau of Microbial Hazards, Health Protection Branch, Health and Welfare Canada
2. Food Inspection Division, Health Protection Branch, Health and Welfare Canada

3. National Enteric Reference Centre, Bureau of Bacteriology, Health Protection Branch, Health and Welfare Canada

4. Food and Marketing Branch, Agriculture Canada

5. Poultry Diseases, Contagious Diseases Division, Health of Animals Branch, Agriculture Canada

6. Poultry Division (B.C.) Production and Marketing Branch, Agriculture Canada

7. Animal Pathology Division, Health of Animals Branch, Agriculture Canada

8. Regional Veterinary Director (B.C.) Health of Animals Branch, Agriculture Canada

9. Division of Feeds and Fertilizers, Agriculture Canada

10. Fish Inspection Branch, Fisheries and Oceans Pacific Region, Environment Canada

There could well be more Federal agencies involved but these were the only ones from whom I received letters. From the above information there appear to be three main Federal Departments involved in Salmonella control and they are:

1. Health and Welfare Canada
2. Agriculture Canada
3. Environment Canada

Although it would appear that the Federal Government is the main regulatory agency involved in Salmonella control, the Provincial
Government in British Columbia also is involved. There are three main Ministries involved in British Columbia.

1. Ministry of Agriculture
2. Ministry of Health
3. Ministry of the Environment

A brief summary will be given of the involvement of the various Federal and Provincial agencies, in the control of Salmonella.

I. FEDERAL GOVERNMENT

(1) Health and Welfare Canada

The Department of National Health and Welfare has the overall responsibility of ensuring the safety and wholesomeness of the Canadian food supply. The Federal Food and Drugs Act which is the responsibility of the Department of National Health and Welfare states in part:

Section 4. (a) No person shall sell an article of food that has in it or upon it any poisonous or harmful substance.

Section 5. No person shall label, package, treat, process, sell or advertise any food in a manner that is false, misleading or deceptive or is likely to create an erroneous impression regarding its character, value, quantity, composition, merit or safety.

Section 7. No person shall manufacture, prepare, preserve, package
or store for sale any food under unsanitary conditions.

The Health and Welfare Canada has formulated regulations, which have been promulgated, that prohibit the sale of the following products if they contain Salmonella: cocoa, chocolate, dry milk, egg products, and frogs legs. It is the intention of the Department to add to this list a regulation making it an offence to sell Salmonella contaminated poultry meat. Such a regulation for chicken may read as follows: "No person shall sell the meat of chickens (Gallus domesticus) or chicken meat by-products for use as food unless it is free from bacteria of the genus Salmonella as determined by the Official Method."

A similar regulation will be prepared for turkey. The Official Method includes both the method of analysis and the sampling plan. The method of analysis has been chosen but the sampling plan is still under consideration. The above information was obtained from Dr. H. Pivnick.

In a personal communication from Dr. H. Pivnick, who is the Director of the Bureau of Microbiological Hazards, Food Directorate, Health Protection Branch, he wrote:

"In my view the main source of Salmonella in the Canadian food supply results from the high incidence (about 35%) in poultry carcases. This high incidence results from contaminated feed and infected breeder flocks. The regulations recommended by the Minister's Advisory Committee would if enacted under the Food and Drugs Act, put the pressure on those segments of the poultry industry to take the steps necessary to improve. However as these industries are under the control of
the Department of Agriculture, the Department of National Health and Welfare has no jurisdiction for direct intervention."

The regulation recommended by the Minister's Advisory Committee that Dr. Pivnick refers to is as follows:

It is recommended that an ad hoc committee be established to determine and implement practical ways of controlling Salmonella in dressed poultry. The poultry industries and involved government agencies should be represented on this committee. 79

Health Protection Branch is well aware of the Salmonella problem but is hampered in its efforts to reduce the incidence of Human salmonellosis because of the complexity of the problem and also the involvement of other agencies. However it is monitoring the incidence of Salmonella contaminated poultry carcasses at the retail level, and is proposing microbial standards, and sampling techniques that could be used if legislation is forthcoming.

The National Enteric Reference Centre is also part of the Department of National Health and Welfare and information on foodborne outbreaks is prepared by this agency. These reports include Salmonella food poisonings, and contain information on the etiology, locality, number of people affected, number of people at risk, clinical symptoms, laboratory results and some comments. 33

(2) Agriculture Canada

Through its various branches Agriculture Canada is involved in, poultry feeds, rendering plants, hatcheries, importation of chicks, egg and egg products, poultry processing and many other agricultural
matters.

[A] Poultry Feeds:

Pivnick\textsuperscript{78} wrote "As far as I know there are presently no Federal regulations concerning Salmonella in feeds."

In a letter from Mr. Heney\textsuperscript{80}, Assistant Deputy Minister of Agriculture Canada, he makes the following points.

1. The Plant Products Division's Salmonella sampling program is directed towards protein feed ingredients as well as finished feeds. Meat meal, bone meal and fish meal ingredients are considered the most suspect and therefore, receive the greatest attention. An annual quota of 525 samples are presently allotted to the six districts in the division.

2. The Division identifies sources of contaminated feeds or ingredients and puts forth measures to eliminate the contamination.

3. The past programs have identified an accumulated contamination rate of approximately 30% with 25% attributed to rendered products and 6% to finished feeds.

4. The sampling program and the regulations governing the presence of Salmonella in feeds is currently under review.

It would appear from Mr. Henney's letter that there are only guidelines relating to the contamination of feeds with Salmonella rather than regulations, although he doesn't state what is done when
the feeds are found to be contaminated with Salmonella organisms. However as Pivnick\textsuperscript{77} has pointed out unless regulations are enforced it is unlikely that they will be complied with. If new regulations are drawn up for animal feeds they will have to be properly enforced if they are to be effective.

[B] Rendering Plants:

The Meat Inspection Division works jointly with the Plant Products Division in routinely inspecting and sampling packing house rendering operations and inedible rendering plants. Bacteriological testing is done on the rendered products.\textsuperscript{80}

No mention is made as to what happens when Salmonella organisms are found in the rendered materials. Presumably this question is currently under review as well.

[D] Hatcheries:

Information for this section was supplied by Mr. J. Raffa,\textsuperscript{81} District Director Poultry Division (B.C.) Production and Marketing Branch, Agriculture Canada.

Under the Federal and B.C. Hatchery Regulations there is a program of fluff sampling of all hatchery incubators from each hatchery. Samples are taken every six weeks and the fluff samples are analysed for Salmonella. If Salmonella is identified then discussions take place between the Poultry Division of Agriculture Canada, and the B.C. Poultry Branch as to the source of the infection.
In a report prepared by Dr. D'Aoust and Dr. Pivnick it was stated that fluff samples collected from hatching machines by federal inspectors are tested in provincial laboratories. When Salmonella contaminated fluff is identified, the multiplier flock(s) producing the contaminated hatching eggs is traced and tested; if found to be highly infected, the flock is destroyed.  

In addition fumigation with formaldehyde is routinely used to sanitize hatching eggs and hatchery equipment.

[D] Importation of Young Chicks:

Information for this section was also supplied by Mr. J. Raffa of Agriculture Canada.

"We do not have a program for testing of imported chicks for Salmonella. Very recently we have arranged with Dr. W. Dorward, Director, Health of Animals Branch Laboratory, Vancouver, to provide him with imported chick specimens. He will be diagnosing these for Salmonella. This will be a three month program of an unofficial nature to determine whether there is any Salmonella in imported chicks."

Dr. D. J. Hawkins, Regional Veterinary Director (B.C.) Agriculture Canada, wrote:

"Poultry imported into Canada are from Salmonella pullorum free flocks only as far as Salmonella is concerned. On arrival birds are examined visually, and last year 443,000 chicks were imported into British Columbia."
Egg and Egg Products:

Information for this section has been supplied by Mr. J. Raffa of Agriculture Canada.

There are no regulations pertaining to the testing of commercial eggs for Salmonella. March in a study where she sampled the contents of (3,995) intact eggs (i.e. not cracked) for Salmonella found no Salmonella, even though many of the intact egg shells were contaminated with Salmonella organisms.

Federal Egg Regulations state that eggs graded Canada C (this grade now includes cracks as well as eggs of "C" quality) when moving to another province must be conveyed to a registered egg product station (egg breaking plant), in that other province.

Federal Processed Egg Regulations stated that "No person shall sell any egg product for use as food unless it is free from bacteria of the genus Salmonella as determined by the Official Method. (Food and Drugs Act)

Sampling of egg products is done on a randomized basis. However all egg products are sampled extensively, and there are definite sampling procedures. When the Poultry Division has been informed that a lot is positive for Salmonella, Health Protection Branch is notified and the lot is seized.

In 1977 there were 2,783 analyses performed on liquid and frozen processed egg products, and 1,101 analyses on dried processed egg products which includes a small percentage of imports with less
than 0.5% positive for all types of processed egg.\textsuperscript{30}

These regulations only came into effect in Canada in November 1976 so it is too early yet to judge how effective they are.

[F] \textbf{Poultry Processing}:

Although poultry carcasses are monitored for the presence of Salmonella both by the Health of Animals Branch, Agriculture Canada, and by Health Protection Branch, Health and Welfare Canada, there are no regulations.

Information below has been supplied by Mr. G. B. Morgan\textsuperscript{85} of the Health Protection Branch.

"Some poultry processing plants fall under the Federal Health of Animals, or Provincial Veterinary Service Inspection programs. Small firms that are not inspected by Provincial or Federal Agriculture Departments fall under our jurisdiction, however our inspection of these plants would not exceed one inspection per year. Our region also covers Alberta and in that Province all poultry plants are under the jurisdiction of the Federal or Provincial Agriculture Departments.

Our sampling of poultry products takes place at the producer level and includes both Federally registered and non-Federally registered plants. Three firms in British Columbia will be sampled this year, and our sampling requirements are that one specimen will consist of five whole fresh birds. These are
to be chosen at random from one lot and a lot is defined as the daily shipment from an individual grower."

At the present time Agriculture Canada has no regulations that help to control the incidence of Salmonella-contaminated poultry carcasses at the retail level.

(3) **Environment Canada**

The following information is about fish meals and was supplied by Mr. C. Campbell, Operations Manager Fish Inspection Branch.

"In 1976 almost 10,000 tons of fish meal was produced in British Columbia. Although we don't have any figures on the ultimate uses of this meal, we could say a significant proportion would be used as a supplement for poultry feeds.

All fish meal is tested for Salmonella before marketing. Sampling by our Fish Inspection staff is on a daily basis and consists of 1 sample per date code. The sample size is 1 kg from which 50 g is used as an inoculum.

The Feeds Act and Regulations, enforced by Agriculture Canada, requires meal be Salmonella-free. Our Fisheries Inspection Branch has agreed to carry out the monitoring, analyses and enforcement of the regulations regarding fish meal.

If a lot of fish meal is found to be contaminated with Salmonella, the lot is placed under detention and the meal must be destroyed or reprocessed under supervision. The reprocessed lot is then heavily sampled and tested and must
be Salmonella-free before it is released for marketing.

Normally, under good commercial practice, the first 30 minutes of production each day is re-cycled back through the driers. Salmonella contamination usually originates after the meal has left the drier as the meal temperature in the drier is sufficient to kill Salmonella organisms.

Fish oils are marketed for use in margerines, cosmetics, paints, etc. and because of the heat process involved in refining, they are not likely to contain Salmonella. Testing for Salmonella is therefore not conducted."

From the above description by Mr. Campbell, fish meals would appear not to be a very likely source of Salmonella organisms when added to poultry feeds, unless they had been mishandled between the fish reduction plant and the poultry feed plant.

II  BRITISH COLUMBIA PROVINCIAL GOVERNMENT

(1)  Ministry of Agriculture

The following information was supplied by Mr. S. B. Peterson, Deputy Minister of Agriculture, Province of British Columbia.

"There are two areas in which some form of Salmonella is controlled, the first being the Hatchery Regulations under the Poultry and Poultry Products Act. These regulations require that all breeders be free of Salmonella pullorum. Blood testing of breeder flocks was carried out for years to the point where over one million chickens were tested with no reactors. A
monitoring program is continuing. The other area is that of meat inspection where any poultry carcass showing any lesions is discarded. There is no specific test for Salmonella."

A letter from Mr. C. W. Wood, Head, Poultry Branch, Ministry of Agriculture, Province of British Columbia, makes the same points and adds that the regulations are the same for chickens and turkeys.

Mr. J. Raffa in a letter states:

"The B.C. - Shell Egg Regulations state that no person shall sell, offer for sale, send or convey from any place to any other place eggs marked Canada 'C', except to an egg product station for the purpose of processing into egg product. This now means that "cracks" now included in Canada 'C' grade are regulated and can only move to an egg products station. However, egg producers in the province are eligible to sell "cracks" produced on their own farms at the farm gate only."

In summary there is no routine testing for Salmonella serotypes other than pullorum in the poultry industry. Carcasses in poultry processing plants are inspected for gross evidence of Salmonella infections, but no bacteriological testing is performed. Salmonellae other than S. pullorum are not reportable.

(2) Ministry of Health

Human salmonellosis is a reportable disease in British Columbia. Upon notification the physician reporting the case is requested to fill
out a form, which seeks further epidemiological information, together with information on household contacts and treatment.

The regulations for salmonellosis (other than typhoid and paratyphoid) as printed in the "Regulations for the Control of Communicable Diseases", are as follows:

Salmonellosis (other than typhoid and paratyphoid fever)

(i) The person shall be placed in modified isolation, as defined in clause (b) of subsection (1) of Division 4, during the period of acute illness.

(ii) The person shall be excluded from occupations involving contact with young children or the preparation or serving of food until three consecutive stool cultures, taken not less than 24 hours apart and in the absence of recent antibiotic or chemotherapeutic treatment, have failed to reveal the infectious agent.

(iii) The stool of the person shall be concurrently disinfected.

(iv) The equipment used in the care of the person and the room wherein the person has been cared for shall, on the release of the person from isolation, be subjected to terminal cleaning.

(v) The household contacts of the person shall be excluded from occupations involving contact with young children or the preparation or serving of food until three consecutive stool cultures, taken not less than 24 hours apart and in the absence of recent antibiotic or chemotherapeutic treatment, have failed to reveal the infectious agent.

These regulations apply both to the person who has salmonellosis and the household contacts as stated in subsection (5).
Although no specific mention of Salmonella is made in the British Columbia "Regulations Governing the Sanitation and Operation of Food Premises" there are certain sections of the regulations, which if correctly carried out will help to ensure that commercial food establishments (i.e. restaurants, catering businesses) handle the preparation of food in a sanitary way. Below are some of the sections of the above mentioned regulations.

2.05 No person shall operate a restaurant or catering business unless he is the holder of a valid subsisting permit, issued annually by the Medical Health Officer in the form shown in Appendix A, and unless these regulations are complied with. Such permits shall not be transferable and shall only be issued after the Medical Health Officer is satisfied that the applicant has sufficient knowledge of modern food-handling practices and has available adequate equipment to enable him to operate in a safe and sanitary manner.

2.06 Notwithstanding section 2.05 of Division II of these regulations, where the Medical Health Officer is satisfied that the applicant has sufficient knowledge of modern food-handling practice and has available adequate equipment to enable him to operate in a safe and sanitary manner, the Medical Health Officer may issue a nontransferable interim permit for a period not exceeding one year.

2.07 Every voluntary caterer acting in accordance with section 2.06 shall, before performing the act of voluntary catering, obtain, from the Medical Health Officer, an interim permit in the form shown on Appendix A.
4.01 No person shall be employed in a food premises who is suffering from or is the carrier of, any communicable disease, and it shall be the duty of the proprietor to suspend any person who is suffering from, or is the carrier of, a communicable disease and to report the suspended person's name and address to the Medical Health Officer.

4.02 The Medical Health Officer may, if he believes any person is suffering from, or is the carrier of, a communicable disease, prohibit the person from performing the duties of a food-handler. The person shall be excluded from employment in any food premises until the Medical Health Officer is satisfied that the person is free of any communicable disease that may be spread through the medium of food.

4.03 A proprietor who permits a person to handle or prepare food after having received an order prohibiting the employment of the person for the purpose of handling or preparing food shall be guilty of an offence against these regulations.

4.04 Every food-handler shall

(a) observe good personal hygiene;
(b) wear clean garments and clean footwear;
(c) while on duty refrain from smoking in any area or room where food is prepared, processed, stored, or served;
(d) wash his hands thoroughly before commencing duty and after using the toilet.

There is also a Managers Manual available through the Ministry of Health, and this is made available to all restaurants and catering businesses. At the back of this manual is an examination section that
the Medical Health Officer may wish to use if he is doubtful that an applicant for a permit has sufficient knowledge of modern food-handling practices.

(3) **Ministry of the Environment**

Pollution Control Objectives for food-processing, agriculturally orientated, and other Miscellaneous Industries was published in 1975. The purpose behind the establishment and use of these objectives is to maintain and preserve the land, water, and air environment of British Columbia at the highest possible level. These objectives are now the Pollution Control Board's policy, and below are two excerpts from the published objectives.

4.6.3 **Poultry-Processing**

Effluent objectives are given in Table VII and cover the operations of killing, bleeding, scalding, plucking, eviscerating, washing, and chilling. The rendering operation is not included.

The objectives cover the processing of chickens, ducks, turkeys, and geese and are given as pounds of pollutant per 1,000 pounds of live weight killed. When objectives are expressed in this form, the same values can be used for all poultry. For chickens and ducks, it may be useful to express objectives in terms of pound of contaminant per 1,000 birds and the appropriate bird weight to be used for the conversion is given as a footnote to Table IX.

The treatment required to reach these objectives may comprise combination of blood-recovery systems, grease traps, screens flotation processes, trickling filters, activated sludge processes, and lagoons. Disposal of effluent to the ground should be encouraged, especially for
small operations. In such instances measures must be taken to remove fat which can cause soil plugging. All discharges should be monitored for nitrogen either in the ammonia or nitrate form.

**TABLE IX**

OBJECTIVES FOR THE DISCHARGE OF EFFLUENT TO MARINE AND FRESH WATERS FROM POULTRY-PROCESSING PLANTS

<table>
<thead>
<tr>
<th>Level</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Monitoring Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BOD&lt;sub&gt;5&lt;/sub&gt;, lb./1,000 lb. live weight killed</td>
<td>0.64</td>
<td>1.9</td>
<td>6.4</td>
<td>Weekly</td>
</tr>
<tr>
<td>Suspended solids, lb./1,000 lb. live weight killed</td>
<td>0.54</td>
<td>0.81</td>
<td>2.7</td>
<td>Weekly</td>
</tr>
<tr>
<td>Grease, lb./1,000 lb. live weight killed</td>
<td>0.18</td>
<td>0.21</td>
<td>0.6</td>
<td>Weekly</td>
</tr>
</tbody>
</table>

**NOTE** - To convert live weight to number of birds in Table VII, use the following values:

Chicken average weight = 4.8 pounds.
Duck average weight = 6.5 pounds.

POLLUTION CONTROL OBJECTIVES

It is interesting to note that there is no mention about the bacteriological content of the effluent. Tennant when he studied Salmonella in poultry packing plant effluents found that

"1. Salmonellae were present in raw and treated liquid wastes from three large, well-operated Ontario poultry packing plants. The presence of these pathogenic bacteria in effluents discharged to the environment should not be permitted;
2. Effective chlorination of treated effluent before discharge, as observed at one processing plant, appeared to eliminate salmonellae from the effluent. Further study of chlorination efficiency, and of alternative methods of disinfection, including ozonation, is required."

Tennant further went on to recommend that:

"1. Disinfection of poultry processing plant wastes be required before discharge of the treated wastes to receiving streams or to land;

2. The Environmental Protection Service support studies designed to assess, and establish effective procedures for, the treatment and disinfection of poultry processing plant wastes which will eliminate the discharge of effluents containing salmonellae to the environment."
SALMONELLA CONTROL IN SOME OTHER COUNTRIES

Suzuki in Japan examined samples of imported chicken for Salmonella contamination from seven countries and found that there was a great variation between countries, ranging from 3.8% contaminated to 28.5% contaminated. This study was done in 1971 and 1972 (see Table II). Since that time further studies have been done, and below (Table X) contains information from four sources. Because this information is from four sources the actual figures are not truly comparable due to different techniques used, but it does give an indication of which countries are controlling the Salmonella problem better than others.

**TABLE X**

PERCENTAGE OF SALMONELLA-CONTAMINATED RAW DRESSED CHICKEN 1973–1974

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Sweden (Findus Co.)</td>
<td>0</td>
</tr>
<tr>
<td>2.</td>
<td>Denmark</td>
<td>≤4</td>
</tr>
<tr>
<td>3.</td>
<td>Hungary</td>
<td>6</td>
</tr>
<tr>
<td>4.</td>
<td>Turkey</td>
<td>8</td>
</tr>
<tr>
<td>5.</td>
<td>China</td>
<td>10</td>
</tr>
<tr>
<td>6.</td>
<td>U. S. A.</td>
<td>11</td>
</tr>
<tr>
<td>7.</td>
<td>Bulgaria</td>
<td>14</td>
</tr>
</tbody>
</table>
| 8.   | Belgium
|      | France                   | 17      |
| 10.  | Canada                   | 18      |
| 11.  | Netherlands              | 29      |
| 12.  | Germany                  | 61      |
The sources for Table X are as follows:

A. Siems et al 1974; 503 carcasses produced in or imported into Germany. 93

B. Suzuki et al 1973; 6,523 carcasses imported into Japan. 4

C. Lundbeck 1974; 8,415 samples produced by Findus A B in Sweden. 94

D. Health Protection Branch, Canada; 157 carcasses from 5 geographical areas in Canada. 3

From this data in Table X, Canada is ranked in tenth position out of the twelve countries used for this comparison. Since this study was done Health Protection Branch Canada, changed its analytical methodology in 1974, and the percentage of contaminated poultry for the 1976 - 1977 period was reported as being 39%, which if there was no change in the other countries listed, would place Canada in eleventh position.

In the next part of this paper control measures being used in some countries will be examined.

SWEDEN

Information on control measures being employed by the Findus AB Company in Sweden has been supplied by Holgar Lundbeck 94 and the following is a brief description of the different measures by which an industry of moderate size (approximately 3 million chickens a year) was able to reduce the frequency of Salmonella infections to insignificant levels.
It was realized by the company that there were seven important ways in which Salmonellae was spread among chickens, and these were:

1. The breeding flocks
2. The Feeds and Water
3. Transportation
4. Slaughter
5. Control of Rodents and Insects
6. Waste Disposal
7. Examination of Plant Personnel

Of these seven points listed above the first two were considered to be the most important.

1. The Breeding Flocks:

Animals for breeding were secured by contract with special producers within the country. These producers deliver chickens one day old which are reared separately under rigid control for 12 weeks and then transported to the breeding stations. The eggs are fumigated with Formalin as are the newly hatched chickens. The health condition of the breeding stock is continuously checked by veterinarians, and a special agreement with the health authorities involving insurance for losses due to the occurrence of Salmonellae in the chickens has been arranged.

2. Feeds and Water:

The Findus Company were of the opinion that it is absolutely essential to have feeds which are free of Salmonella organisms. Only pellets, heated to a minimum temperature of $70^\circ C$ for half a minute
are used for feeding purposes. The pellets are regularly checked by bacteriological examination. The pelleted feed is distributed by automatic mechanical devices, and these are cleaned between each flock of chickens.

Water is distributed automatically and only potable water satisfying official criteria for human consumption is used. Rills and cups are cleaned daily.

3. **Transport:**

Cages for transport, because they move between different rearing houses, are cleaned in a special washing machine.

4. **Slaughter:**

There are four stations within the processing plant which are separated from each other. The tools and personnel in each of the four stations are not interchanged. During evisceration, if there is any damage to the abdominal contents, then that particular bird is discarded.

After evisceration the carcasses are rinsed and chilled in spin chillers, and the water used in this process is chlorinated to a concentration of 1 to 5 p.p.m., and the chlorine concentration is checked twice a day.

Specimens of the spin-chiller water are examined once a day for Salmonella.

The processing plant is cleaned every night and the equipment and
conveyor belts are cleaned with chlorinated water (10 p.p.m.) from high pressure hoses.

5. **Control of Rodents and Insects:**

   A specialized firm is employed to deal with this problem.

6. **Waste Disposal:**

   Waste is collected in rills of stainless steel and transported with the aid of highly chlorinated water to containers outside the slaughter house, and these wastes are transported twice a day to special stations for disposal.

7. **Personnel:**

   Fecal specimens are examined for Salmonella, from all personnel working in the plant twice a year. Also if any personnel have travelled out of the country they are rechecked before starting work again at the plant.

   In conclusion the Findus Company states that, "Salmonella contamination of chicken products can be practically completely ruled out by systematic planning of the whole production chain. The costs are well within tolerable limits."

   The above description applied to the Findus Company, but Sweden has other nation wide controls and some of these are:

1. There is a voluntary programme for Salmonella control in poultry
and 90% of all broiler producers are members of the scheme.

2. All Salmonella isolations from animals, food, feedstuffs, and the environment must be notified. The National Veterinary Institute acts as the national reference centre and passes information to the Board of Agriculture, the state epizootiologist, and county veterinary organizations.

3. In the control of Salmonella, compensation is paid by the government for production losses, and for animals slaughtered.

4. Imported feedstuffs of animal origin are examined bacteriologically before entry, and any consignments found to be contaminated with Salmonella are not accepted.

From the above description the problem of the control of Salmonella organisms in the poultry industry has been taken seriously in Sweden. The effectiveness of these measures can be seen by looking at the very low percentage of Salmonella-contaminated processed poultry.

DENMARK

Since 1954, bone meal, meat and bone meal, blood meal and composite feed containing these ingredients are resterilized when imported into the country. Since 1957 fish meal and certain other fish products, other than those from a limited number of countries of low risk, are sterilized at the time of importation.

There are 18 sterilization plants, and they are all closely
supervised by the veterinary service. These plants are used for the sterilization of protein material, all carcasses and inedible offal including poultry waste.

**Breeding Stock:**

There is only one large breeding centre for broilers, which is monitored for Salmonella. Imported birds are quarantined before being mixed with the other breeding stock.

**Hatcheries:**

In 1964 an Order was issued that stated "geese, ducks and turkeys must at no time be found on a property on which there is a hatchery, or from which hatching eggs or poultry are supplied to a hatchery."

**Special Control Measures for Salmonellosis:**

These five control measures were mentioned by Marthedal in a paper presented at an International Symposium on Salmonella.95

1. Breeding Centres - The breeding stock of the centres shall be blood tested for specific S. typhimurium reaction, all animals being examined at the age of 5 months, when they have just started laying, and before the eggs are taken for hatching. If the S. typhimurium reaction is positive, the reactors are sent for bacteriological control.

2. A representative selection from each hatching (2 x 10 to 15 chickens)
are forwarded at 8 - 10 day intervals, beginning one week after hatching to the Institute of Poultry Diseases for bacteriological examination.

3. From the age of 1 month a representative selection of animals is sent in for laboratory testing, including bacteriological examination.

4. Shortly before the breeding stock is sent to the processing plant blood samples are again taken from all animals and examined for S. typhimurium infections.

5. Grandparent animals are mostly subjected to the same examinations described in the above four points.

If samples reaching the Institute of Poultry Diseases are positive for Salmonella the epidemiological studies are performed to try and determine the source of the original infection, and further control measures can then be applied if necessary.

Marthedal in his discussion states that "There is no doubt that the introduction of a number of preventive measures in Denmark during the years has contributed to reduction of the frequency of Salmonellosis in Danish poultry and consequently in man. Total eradication is by now probably impossible as the potential risks of infection are numerous."

UNITED KINGDOM

In the early 1970's there was a serious outbreak of S. paratyphi B. which involved both dairy cattle and humans, and at the time it became
apparent that the Agricultural Department had no powers to control the outbreak. The absence of such powers meant that the Departments were unable to act compulsorily to safeguard human health from infection in animals, no matter how serious.

Because of this inability to protect the public the Zoonoses Order (1975)\(^96\) was promulgated. The Order designates diseases of animals, or organisms carried in them, that are considered to constitute a risk to human health. Under these powers, cases involving a designated disease of animals or poultry, or the presence of designated organisms in them, can be dealt with by compulsory measures to safeguard human health. The Zoonoses Order (1975) is the first Order to be made under these powers and designates the Salmonella and Brucella organisms specifically.

The Order provides for:

1. A compulsory reporting procedure.
2. The investigation of cases.
3. The emergency measures to protect human health.\(^96\)

In a letter from Mr. A Brown, Chief Veterinary Officer, of the Ministry of Agriculture, Fisheries, and Food, in England, the following information is given.

"1. There are as yet no specific regulations regarding poultry feeding stuffs. It had been our intention to introduce a Protein Processing Order at the same time as the Zoonoses Order, with the object of ensuring that all ingredients incorporated into all animal
feeds were rendered Salmonella free by heat treatment. Unfortunately this was not possible, but we are optimistic that such an Order will be introduced later this year (1978).

2. There are no special regulations regarding Salmonella infections in poultry flocks in the Ministry's Poultry Health Scheme. This scheme ensures that all flocks are free of S. pullorum and S. gallinarum only."

Thus it would appear that the United Kingdom is making efforts to control human salmonellosis, through a compulsory reporting system, together with investigation, of animal salmonellosis, and that the importance of Salmonella organisms in the feeds is recognized.
CONCLUSIONS

Many individuals and national committees have made extensive recommendations regarding the control of salmonellosis both in poultry and man. 25,55,98,99,100,101

These recommendations apply to every aspect of the poultry industry from the egg to the poultry processing plant, and include feed stuffs and the disposal of waste material. Also recommendations have been made for the correct handling and cooking of poultry both in food catering establishments and the home. There is no doubt that if all these recommendations were put in to practice, human salmonellosis resulting from poultry would be a very rare event indeed.

However all these recommendations would if implemented, lead to some additional cost, which would eventually be borne by the consumer. If, because many of these recommendations were put into practice, the price of poultry was greatly increased then the consumption of poultry would decrease, for people would tend to consume cheaper and alternate foods. Thus it is possible that poultry could become too expensive even though it was completely free of Salmonella contamination.

Thus some happy medium has to be reached or alternatively some relatively inexpensive method found, so that poultry at the retail level would be free of Salmonella contamination.

When dealing with the question of whether eradication or control of Salmonella should be the goal in Canada, there would appear to be very little doubt that eradication is probably impossible and that control is all that can be expected, at the present time, with the
present technology at our disposal. However it may be possible to produce Salmonella free poultry at the retail level even though Salmonella is not well controlled in the poultry flocks. This possibility will be dealt with later under research.

If Canada is really serious about the control of salmonellosis in poultry and man, then both poultry salmonellosis and human salmonellosis must be reportable diseases, as is the case in some countries (Sweden and Denmark). Once salmonellosis is reported an epidemiological investigation should be carried out, as is the case in Denmark where veterinary and medical personnel work together as a team in such investigations, and regulations such as the Zoonoses Order in England be available to deal effectively with such outbreaks.

It is my personal impression that there are too many branches of both Federal and Provincial Governments involved in Salmonella control, and that there is no control co-ordination of these efforts. If Salmonella is to be effectively controlled, a Canada-wide "Salmonella Control Program", must be established. This program, because of the nature of the Canadian political system, would have to be policed at the Federal level, and such parts of the program as reporting of cases, enforcement of regulations, and evaluation of methods, would have to be rigidly controlled at the Federal level.

New regulations would have to be drawn up and these would have to be made in consultation with Federal and Provincial Governments together with input from the poultry industry. Once such a program has been set up there must be very definite methods employed to make sure that it is adhered to. As Pivnick pointed out unless regulations
and guidelines are enforced and definite penalties can be, and are applied to those not conforming to the program, then such a program will be ineffective.

Before any such program is fully operational a research team should be set up. There are two reasons for this. First of all, there is a voluminous amount of literature dealing with Salmonella control which should be evaluated, and secondly studies should be carried out on those methods which appear to be most cost-effective, and further research into new methods of control should be carried out. Some areas where I feel research should be undertaken could include:

1. The effectiveness of colonizing young chicks intestinal flora in order to prevent poultry salmonellosis. Such studies are being carried out by Nurmi, Rantala and by some groups in Canada.

2. The use of ionizing radiation should be investigated, and if found to be effective and acceptable, then new regulations will have to be promulgated. It is interesting to note that in Canada onions and potatoes can be treated with ionizing radiation before being sold, but poultry cannot be. The work of Mulder and others should be followed up, for it may be possible by the use of radiation, to completely decontaminate poultry before they reach the retail level, without any risk to human life. Such a method could possibly solve the problem that is the subject of this thesis.

3. The chlorination of rinse water in processing plants is another area that might be very effective in decontaminating poultry.
These are just a few of the possible ideas that should be researched, for if they are found to be effective an entire program such as is being used in Sweden would not be necessary, and probably it would be a much less expensive method of controlling the problem.

If poultry cannot be completely decontaminated at the retail level, then educational programs will be required for consumers and food handlers on the importance of food safety during food preparation and storage.

In this thesis I have attempted to demonstrate the present situation in Canada regarding the involvement of Salmonella contaminated processed poultry and human salmonellosis, and the costs to the country of this preventable situation. Methods used for Salmonella control in some countries have been described, and finally some recommendations have been presented on how this problem could be dealt with in Canada.
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