Protecting the U.S. Food Supply in a Global Economy: An Expert Gap Analysis

by

Paul A. Hall


DISSERTATION.COM

USA • 2002
Protecting the U.S. Food Supply in a Global Economy:  
An Expert Gap Analysis

A Dissertation in Fulfillment of the Requirement for  
the Degree of Doctor of Philosophy in  
Total Quality Management
At  
LaSalle University  
Mandeville, Louisiana

Submitted by  
Paul Anthony Hall  
September 14, 2001
This work is dedicated to the loving memory of my mother and father, Edna Lois Hall and James Benjamin Hall. Though they no longer walk this earth, their love and inspiration endures.
“The world really is just one village. Our tolerance of disease in any place in the world is at our own peril.”

“Rapid globalization of human niches requires that human beings everywhere on the planet go beyond viewing their neighborhoods, provinces, countries, or hemispheres as the sum total of their personal ecospheres.”
Abstract

Diligent application of the Hazard Analysis and Critical Control Point (HACCP) approach is believed by many to provide a comprehensive system for food safety management. This belief, however, is not shared uniformly by all stakeholders. Because of the dichotomy of opinion surrounding food safety, there is a compelling need for additional dialogue and consensus on this issue. The aim of this expert survey instrument is to identify the gaps and the areas of agreement among various stakeholders. Two hundred and thirty-one survey instruments were received out of three hundred and sixty sent (64.2% response rate) to food safety professionals in academia, industry, federal and state government, and consumer protection groups. The survey consisted of four parts: I. A series of statements across the food chain describing the extent to which respondents agree with each statement; II. Rank order priority ratings and degree of satisfaction/dissatisfaction with 14 issues; III. Weighted priority rankings for 10 issues; and IV. Verbatim comments. The data suggests broad support for: 1. More consistent application of HACCP by industry and government; 2. Development of a comprehensive K-12 food safety education program by the federal government and industry; 3. Increased federal funding for microbiological food safety research; 4. Increased focus on on-farm practices for controlling pathogens; and 5. Increased focus on the microbiological safety of imported food products. There is little support for: 1. Increased investment to control microbial pollutants in U.S. surface and ground water supplies; 2. Increased federal food safety inspection programs; 3. Increased use of finished product microbiological testing; and 4. Development of a comprehensive global foodborne disease surveillance network. Significant differences exist among stakeholder groups on selected food safety priorities. Continued dialogue is needed to understand the basis for these differences and to develop potential approaches to addressing them.
# Table of Contents

Dedication............................................................................................................................. i  
Epigraph............................................................................................................................... ii  
Abstract .............................................................................................................................. iii  
Table of Contents ................................................................................................................ iv  
List of Illustrations .............................................................................................................. v  
List of Tables ....................................................................................................................... vi  
Acknowledgements ............................................................................................................ ix  
Chapter I: Introduction ....................................................................................................... 1  
Chapter II: Literature Review ............................................................................................. 7  
Chapter III: Methodology .................................................................................................... 70  
Chapter IV: Results and Discussion .................................................................................... 76  
Chapter V: Summary, Conclusions, and Recommendations ............................................. 246  
Appendix I: Expert Survey Instrument Booklet ................................................................. 252  
Appendix II: Verbatim Comments .................................................................................... 277  
Works Cited ......................................................................................................................... 335
List of Illustrations

Figure 1: Estimated frequency of foodborne illness in the United States ................. 3

Figure 2: World population: 1950-2050................................................................. 17
List of Tables

Table 1: Primary factors impacting the problem of emerging infections ....................... 7
Table 2: Target areas for CDC’s emerging infectious disease prevention strategic plan .... 9
Table 3: CAST task force findings on the risks and consequences of foodborne pathogens ............................................................ 11
Table 4: Agricultural imports: quantity indexes, United States, fiscal years 1989-99 .... 13
Table 5: Value of selected imports by principal groups, United States, fiscal years 1995 and 1999 ........................................................................................................ 15
Table 6: Requisites for the prevention and control of antibiotic resistance in agriculture and veterinary medicine ................................................................. 25
Table 7: Projected yearly net migration by race, 1999 to 2050 .................................. 26
Table 8: Percentage of adults consuming high-risk foods and food safety handling practices in the home in five FoodNet sites ................................................. 29
Table 9: Expenditures for food, United States: 1996-1999 ........................................ 31
Table 10: The seven principles of HACCP as defined by the National Advisory Committee on Microbiological Criteria for Food ...................................... 56
Table 11: The risk assessment process as described by the National Research Council .................................................................................................................. 58
Table 12: Conclusions of the President’s Council on Food Safety ............................... 66
Table 13: Stakeholder responses to Part Ia - Agricultural Practices ......................... 82
Table 14: Stakeholder responses to Part Ib - Imported Food Commodities ............. 95
Table 15: Stakeholder responses to Part Ic - Water Safety ....................................... 101
Table 16: Stakeholder responses to Part Id - Food Processing and Distribution .... 112
Table 17: Stakeholder responses to Part Ie - Equipment Design and Sanitation Procedures ........................................................................................................ 127
Table 18: Stakeholder responses to Part If – Worker Training ......................................... 135
Table 19: Stakeholder responses to Part Ig - Product Shelf Life ................................. 141
Table 20: Stakeholder responses to Part Ih - Role of the Consumer ............................. 147
Table 21: Stakeholder responses to Part II - Food Safety Communication and Education ........................................................................................................... 154
Table 22: Stakeholder responses to Part Ij - Restaurant and Foodservice ...................... 161
Table 23: Stakeholder responses to Part Ik - HACCP .................................................... 170
Table 24: Stakeholder responses to Part Ill - Government Inspection and Oversight .......... 184
Table 25: Stakeholder responses to Part Im - Role of Testing ........................................ 195
Table 26: Stakeholder responses to Part In - Global Trends ........................................... 205
Table 27: Microbiological food safety issue priority rankings and satisfaction levels by stakeholder group – industry/large manufacturers ........................................ 215
Table 28: Microbiological food safety issue priority rankings and satisfaction levels by stakeholder group – industry-small to medium manufacturers ........................ 216
Table 29: Microbiological food safety issue priority rankings and satisfaction levels by stakeholder group – industry-foodservice/catering/grocery/restaurant .......... 217
Table 30: Microbiological food safety issue priority rankings and satisfaction levels by stakeholder group – suppliers to industry ................................................ 218
Table 31: Microbiological food safety issue priority rankings and satisfaction levels by stakeholder group – academia ................................................................. 219
Table 32: Microbiological food safety issue priority rankings and satisfaction levels by stakeholder group – consumer protection organizations ............................ 220
Table 33: Microbiological food safety issue priority rankings and satisfaction levels by stakeholder group – government, FDA ............................................................ 221
Table 34: Microbiological food safety issue priority rankings and satisfaction levels by stakeholder group – government, USDA – FSIS .................................................. 222
Table 35: Microbiological food safety issue priority rankings and satisfaction levels by stakeholder group – government, USDA – ARS ................................................... 223
Table 36: Microbiological food safety issue priority rankings and satisfaction levels by stakeholder group – government, CDC ...................................................... 224

Table 37: Microbiological food safety issue priority rankings and satisfaction levels by stakeholder group – government, state and local ........................................... 225

Table 38: Microbiological food safety issue priority rankings and satisfaction levels by stakeholder group – independent organizations, consultants, testing laboratories .................................................................................................... 226

Table 39: Microbiological food safety issue priority rankings and satisfaction levels by stakeholder group – trade organizations .......................................................... 227

Table 40: Overall microbiological food safety issue priority rankings summarized by stakeholder group ........................................................................................... 228

Table 41: Overall microbiological food safety issue priority rankings grouped by frequency of top-ten occurrence .......................................................... 229

Table 42: Overall microbiological food safety issue priority rankings grouped by top-five, middle-five, and bottom-four frequency of occurrence. ......... 230

Table 43: Microbiological food safety issue satisfaction levels across all stakeholder groups ........................................................................................................... 232

Table 44: Microbiological food safety issue dissatisfaction levels from most dissatisfied to least dissatisfied across all stakeholder groups ..................... 233

Table 45: Microbiological food safety issue weighted priority rankings summarized by stakeholder group ..................................................................................... 235

Table 46: Numerical microbiological food safety issue weighted priority rankings summarized by stakeholder group ................................................................. 236

Table 47: Overall numerical microbiological food safety issue weighted priorities summarized by top-five, bottom-five rankings across all stakeholder groups .... 237

Table 48: Overall numerical microbiological food safety issue weighted priorities summarized by top-three, middle-three, and bottom-four rankings across all stakeholder groups ................................................................. 238
Acknowledgements

First, I would like to express my deep, heartfelt appreciation for the gracious support I received from my wife, Deborah Lynn Hall, during the completion of this work. Her love, perseverance, and patience shines as a beacon to everyone around her. I also want to express my love and thanks to my two precious daughters Erin and Kelsey. Their youthful passion and enthusiasm continues to help me get through those occasional rough days.

I am very grateful to Jeffery Hammonds for his creativity and technical assistance during the preparation of the expert survey instrument and this manuscript. This effort would have been much harder without his creative brilliance.

I also want to express my heartfelt gratitude to Joe Kaplan, Joe Meyer, Joel Paulson, Stéphanie Hammonds, and Frank Rossi for their technical help and ideas during various phases of this work.

My deep appreciation also extends to Kraft Foods for allowing me the time and resources for pursuing this endeavor. In particular, I want to thank Peter Boyle, Joan Menke-Schaenzer, and Jean Spence for their support and encouragement during the course of this work. I also want to thank Barbara Bagnuolo for her tireless word processing support.

Finally, I want to thank all of the food safety professionals that participated in the expert survey. Your professionalism and dedication to making the world a healthier and safer place for all is nothing short of remarkable.
This page is intentionally left blank.
Chapter I: Introduction

Foodborne disease continues to be of major concern to public health officials, food manufacturers, academic researchers, and consumer protection groups worldwide. The Food and Agriculture Organization and the World Health Organization have declared that “… access to nutritionally adequate and safe food is a right of each individual”. Despite this declaration, foodborne disease remains a significant cause of morbidity and mortality within the United States and other countries around the world. It has been estimated that each year in the United States, approximately 76 million people experience some form of foodborne disease. Additionally, surveys conducted in several industrialized countries estimate that as high as ten percent of the population experience some form of foodborne illness each year. In developing countries, poor nutrition, improper personal hygiene, and underdeveloped health infrastructure systems greatly exacerbate the situation. The World Health Organization (WHO) has estimated that 1,500 million episodes of diarrhea occur annually in children under the age of five and that an estimated three million die each year from resulting complications. It is believed that up to 70% of these diarrheal episodes arise from foodborne infections.

The Centers for Disease Control and Prevention (CDC), through their Emerging Infections Program, Foodborne Disease Active Surveillance Network (FoodNet), report that the incidence of foodborne illness under surveillance in the United States actually declined from 1986 to 1999. While this is a short-term positive trend, major foodborne outbreaks, nevertheless, continue to occur in the United States. One example is the 1998-99 multistate listeriosis outbreak linked to the consumption of hot dogs from one manufacturer, in which a reported 21 individuals died and over 200 fell ill. Another example is the 1997 hepatitis A
outbreak among school children in the state of Michigan\textsuperscript{13}. A total of 153 school children contracted hepatitis A from eating frozen strawberries as part of the U.S. Department of Agriculture (USDA) sponsored school lunch program. The strawberries were grown in Mexico and imported into the U.S. by a company in southern California who then processed, packed, and froze the strawberries in 30-pound containers for distribution within the United States.

The American Academy of Microbiology, in a report on the current status and future needs of food safety, has concluded, “\textit{Although previous advances, such as pasteurization and refrigeration, and contemporary improvements in hazard analysis and control have significantly improved the safety of the food supply, foodborne disease remains a major cause of morbidity and mortality\textsuperscript{14}.}” This conclusion is supported by the CDC which state that of the 76 million estimated foodborne illnesses in the U.S. each year, known pathogens account for 14 million illnesses, 60,000 hospitalizations, and 1800 deaths (Figure 1)\textsuperscript{4}. They further state that three pathogens, \textit{Salmonella}, \textit{Listeria}, and \textit{Toxoplasma}, are responsible for 1,500 deaths each year. This accounts for more than 75\% of those caused by known pathogens. Of striking significance, however, is the fact that unknown agents account for the remaining estimated 62 million illnesses, 265,000 hospitalizations, and 3,400 deaths each year\textsuperscript{4}.

While there appears to be consensus that the burden of foodborne illness in the United States is too high, there is not uniform consensus on the best approach(es) to reduce the burden. The concept of the Hazard Analysis and Critical Control Point (HACCP) approach to food safety management was first introduced publicly at the 1971 Conference on Food Protection\textsuperscript{15}. HACCP is a systematic approach to food safety management that encompasses the entire food production process literally from farm to table\textsuperscript{16}. It identifies those parts of the
system which are critical to product safety and emphasizes control of microbiological as well as chemical and physical hazards. HACCP is intended to be a preventive program, which minimizes sole dependence on finished product testing. This feature of the HACCP concept is consistent with the philosophy of quality experts such as W. Edwards Deming and others who maintain that dependence on mass finished product testing is costly and is an acknowledgement that the process cannot meet the capability required from predetermined specifications\(^{17,18}\). The sole focus of HACCP is on food safety, which should not be diluted with non-safety related issues such as economic adulteration or product quality. Careful integration of HACCP into quality programs such as ISO-9000 and Total Quality Management (TQM) is believed by many in the food industry to provide a comprehensive system for food safety management, process

---

**Figure 1: Estimated frequency of foodborne illness in the United States.**

**Pathogen-based data**

- **Known Pathogens**
  - Illnesses: 39,000,000
  - Hospitalizations: 163,000
  - Deaths: 1,300

**Symptom-based data**

- **Acute Gastroenteritis**
  - Illnesses: 211,000,000
  - Hospitalizations: 937,000
  - Deaths: 6,400

**Pathogen-based data**

- **Known Pathogens - Non-gastroenteritis**
  - Illnesses: 300,000
  - Hospitalizations: 18,000
  - Deaths: 1,300

- **Known Pathogens - Acute Gastroenteritis**
  - Illnesses: 38,000,000
  - Hospitalizations: 163,000
  - Deaths: 1,400

- **Unknown Agents - Acute Gastroenteritis**
  - Illnesses: 173,000,000
  - Hospitalizations: 774,000
  - Deaths: 5,000

**Symptom-based data**

- **Acute Gastroenteritis**
  - Illnesses: 38,000,000
  - Hospitalizations: 163,000
  - Deaths: 1,500

**Total Burden of Foodborne Illness**

- Illnesses: 120,000,000
- Hospitalizations: 55,000
- Deaths: 900

---

*Percentages derived from observed frequency of foodborne transmission of acute gastroenteritis caused by known pathogens*

*Source: Reference 4.*
optimization, and continuous improvement\textsuperscript{19}. This belief, however, is not uniformly shared by all stakeholders such as consumer protection groups and certain governmental regulatory components such as the USDA’s inspectors union\textsuperscript{20-23}. This point is exemplified by the testimony of the Director of Food Safety for the Center for Science in Public Interest (CSPI) before the U.S. Senate Committee on Governmental Affairs. CSPI is a non-profit organization focused on improving the nation’s health largely through its work on food safety and nutrition issues. In this testimony, CSPI stated that “While FDA’s recent failure at HACCP implementation is troubling, many hope that the widespread use of the regulatory HACCP can and will fundamentally change government’s role in food safety oversight. It won’t happen without more uniform oversight\textsuperscript{24}.”

The skepticism in the inability of HACCP and other current food safety management programs to effectively protect the public stems partly from the fact that large-scale illness outbreaks as discussed earlier continue to occur. It also partly stems from political reasons such as some wishing to maintain the status quo of continuous USDA inspection of meat slaughtering and processing operations\textsuperscript{25,26}. Food safety has also been magnified in the political arena in the U.S.. For example, during a weekly radio address to the nation, former President Clinton announced that he directed the Secretaries of Agriculture and of Health and Human Services to report back to him within 120 days on steps both Departments would take to significantly reduce the risk of illness and death by \textit{Listeria monocytogenes} in ready-to-eat foods\textsuperscript{27}. The former President’s letter to the Secretaries directed the agencies to take several specific actions. Among them is the goal to cut the number of illnesses caused by \textit{Listeria monocytogenes} in half from the current 0.5 cases per 100,000 to 0.25 cases per 100,000 by the year 2005\textsuperscript{28}. It
remains to be seen whether this goal is attainable considering that all of the sources of this organism are not known (e.g., processed foods versus food served in restaurants or food service settings or recontamination by the consumer in the home). Furthermore, while listeriosis has a mortality rate of approximately 20%, it is a relatively rare disease. While the former President’s goal is admirable, focusing on reducing the incidence of illness and death from this one microorganism will have limited impact on reducing the total burden of foodborne illness in the U.S., especially considering that the majority of foodborne illness in the U.S. is caused by unknown agents.

It is clear that there is a need to reduce the level of foodborne disease in the U.S. It is also clear that there is divergence of opinion on the best approach(es) needed to address this critical issue. There are few reports in the literature that have attempted to seek comprehensive input from the various stakeholders across the food safety continuum. Most of the reports in the literature deal narrowly with specific elements of the food safety continuum such as future trends in rapid detection methods or trends in foodborne pathogens and antibiotic resistance. One comprehensive study was conducted by Jarvis in 1983 and employed the Delphi oracle method to forecast trends in food microbiology. This study was a consensus approach across a 29 member expert panel. The panel in this study was compiled subjectively and took no account of whether individuals were employed within a university research institute, industry or consultancy, or whether they had medical, veterinary or other scientific qualifications. The only prerequisite was that the panel members were known to have been working in food microbiology. While this study was illuminating in that it helped food safety professionals consider future trends and needs, it did not include all stakeholders, such as government
regulators or consumer protection groups, nor did it focus on differences of opinion among their stakeholders.

The intent of this current dissertation research is to help provide a framework for a national consensus among the major stakeholders for the best approaches to addressing the complex issues surrounding the safety of the U.S. food supply in a global economy. It explores the divergence of opinion among the major stakeholders and examines the gaps in our scientific knowledge surrounding this issue. Contrasted to the work of Jarvis in 1983, this study includes input from all major stakeholders in the food safety continuum and identifies both areas of agreement and areas of disagreement. It does not attempt to force consensus as in the Delphi oracle method but rather serves as a basis for dialogue, debate and understanding in the attempt to gain a national consensus on the best approaches to this critical public health problem.
Chapter II: Literature Review

In 1992, the Institute of Medicine issued its seminal report on “Emerging Infections: Microbial Threats to Health in the United States.” This report defines emerging infectious diseases as those whose incidence in humans has increased within the past two decades or threatens to increase in the near future. The report also identifies those primary factors that impact the problem of emerging infections. These factors include demographic and environmental conditions that favor the spread of infectious disease (table 1).

<table>
<thead>
<tr>
<th>Table 1: Primary factors impacting the problem of emerging infections.a</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Global travel.</td>
</tr>
<tr>
<td>- Globalization of the food supply and centralized processing of food.</td>
</tr>
<tr>
<td>- Population growth and increased urbanization and crowding.</td>
</tr>
<tr>
<td>- Population movements due to civil wars, famines, and other man-made or natural disasters.</td>
</tr>
<tr>
<td>- Irrigation, deforestation, and reforestation projects that alter the habitats of disease-carrying insects and animals.</td>
</tr>
<tr>
<td>- Human behaviors, such as intravenous drug use and risky sexual behavior.</td>
</tr>
<tr>
<td>- Increased use of antimicrobial agents and pesticides, hastening the development of resistance.</td>
</tr>
<tr>
<td>- Increased human contact with tropical rain forests and other wilderness habitats that are reservoirs for insects and animals that harbor unknown infectious agents.</td>
</tr>
</tbody>
</table>

*a Source: Adapted from Reference 37*

A number of the identified factors impacting emerging human infections are related to food such as globalization of the food supply and the trend to more centralized processing of
food, irrigation practices, and the increased use of antimicrobial agents in food production. In response to the Institute of Medicine’s 1992 report, the U.S. Centers for Disease Control and Prevention (CDC) developed a comprehensive strategic plan to address the threat of emerging infectious diseases in 1994 and an updated strategic plan in 1998.

The goals of CDC’s comprehensive strategic plan cover four areas:

- **Goal I – Surveillance and response**, with the objectives of strengthening infectious disease surveillance and response in the U.S. and internationally;
- **Goal II – Applied research**, with the objectives of developing improved tools for identifying and understanding emerging infectious diseases, their risk factors, and prevention/control strategies;
- **Goal III – Infrastructure and training**, with the objectives of enhancing epidemiologic and laboratory capacity within the U.S. and internationally; and
- **Goal IV – Prevention and control**, with the objectives of partnering with stakeholders such as other government agencies, private industry, professional societies, and other groups to implement, support, and evaluate disease prevention in the U.S. and internationally. The CDC has identified nine target areas of emerging infectious disease problems and at-risk populations that are of high priority during the implementation of their strategic plan (Table 2).

As shown in table 2, the role of food and food production is a prominent element in CDC’s strategic plan for controlling emerging infectious diseases in humans. While CDC’s strategic plan is comprehensive, it has been suggested that the public health infrastructure in the U.S. and abroad cannot and will not keep up with these infections unless our collective efforts are refocused and the proper resources provided to respond.
As discussed in CDC’s strategic plan for addressing emerging infectious diseases in humans, there is a compelling need to address the issue of foodborne disease if the strategy is to be successful. This is further supported in the 1996 report of the U.S. General Accounting Office (GAO) to Congressional Committees which states “while the precise cost of foodborne illnesses is unknown, recent estimates range from over $5 billion to more than $22 billion annually”\(^39\). This GAO report concludes that current data do not provide sufficient detail on the risk posed by foodborne illnesses and that better data could lead to more effective control strategies. The GAO report, however, does not speculate on what those more effective control strategies might be. Additionally, protecting the U.S. food supply is not only a matter of national priority, but it is international in scope. An expert consultation group of the Food and Agriculture Organization of the United Nations (FAO) and the WHO convened in 1999 to discuss the risk assessment of microbiological hazards in food. This expert group recognized

<table>
<thead>
<tr>
<th>Table 2: Target areas for CDC’s emerging infectious disease prevention strategic plan.(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Antimicrobial resistance.</td>
</tr>
<tr>
<td>• Foodborne and waterborne diseases.</td>
</tr>
<tr>
<td>• Vectorborne and zoonotic diseases.</td>
</tr>
<tr>
<td>• Diseases transmitted through blood transfusions or blood products.</td>
</tr>
<tr>
<td>• Chronic diseases caused by infectious agents.</td>
</tr>
<tr>
<td>• Vaccine development and use.</td>
</tr>
<tr>
<td>• Diseases of people with impaired host defenses.</td>
</tr>
<tr>
<td>• Diseases of pregnant women and newborns.</td>
</tr>
<tr>
<td>• Diseases of travelers, immigrants, and refugees.</td>
</tr>
</tbody>
</table>

\(^a\) Source: Adapted from reference 37
that the globalization of food trade combined with emerging or re-emerging foodborne diseases have increased the risk of cross-border transmission of foodborne agents. This group recognized the strong need to estimate the risk that foodborne pathogens pose to human health in an international context and to identify possible interventions to reduce or eliminate the risks. This group further recognized that “Food safety measures are not uniform around the world and such differences can lead to trade disagreements among countries. This is particularly true if microbiological requirements are not justified scientifically”

In recognition of the issues surrounding the microbiological safety of the food supply, a task force was commissioned by the Council for Agricultural Science and Technology (CAST) to determine the state of knowledge about U.S. foodborne disease risks. In its 1994 report on “Foodborne Pathogens: Risks and Consequences”, this expert task force issued a number of findings relative to the microbiological safety of the U.S. food supply (Table 3).

Based on these findings, the CAST expert Task Force issued a number of recommendations for reducing foodborne illness. These recommendations are consistent with the CDC’s strategic plan for controlling emerging infectious diseases. For example, the CAST Task Force recommended that vigorous fundamental and applied research efforts related to food safety be encouraged and supported, that rigorous epidemiological studies be conducted to assist in establishing the cause of illness, and that at-risk populations be identified so that special control programs can be devised to protect them. One
key recommendation by this expert task force was that federal food safety regulations be modified to reflect that zero risk of foodborne illness is not possible. Recognizing that zero risk is not possible, the task force further recommended that the public be well-educated regarding safe food handling and the relative and changing risk status of individuals.

Table 3: CAST task force findings on the risks and consequences of foodborne pathogens
d
- A comprehensive system of addressing the risks of human illness from microbial pathogens in the food supply has yet to be devised.
- Although foods of animal origin most often are identified as the vehicles of foodborne disease outbreaks, a wide variety of foods are associated with foodborne illness.
- No agreed-upon method for setting food safety priorities exist.
- It is difficult to use available statistics to identify the foodborne component of total human illness.
- Control methods affect specific pathogens and toxins differently; no one method will eliminate all pathogens and toxins from the food chain.
- Application of Hazard Analysis Critical Control Point (HACCP) systems can reduce the likelihood of foodborne illness.

\textsuperscript{a} Source: Adapted from reference 41.

Recognizing the impact of foodborne disease on our society, the American Academy of Microbiology convened a colloquium in 1998 to discuss the issue and identify future research directions. One of the key observations of this colloquium was the fact that “Although