Revised: Quantitative Assessment of Relative Risk to Public Health from Foodborne *Listeria monocytogenes* Among Selected Categories of Ready-to-Eat Foods

I. INTRODUCTION

The United States DHHS Food and Drug Administration's Center for Food Safety and Applied Nutrition (FDA/CFSAN) conducted this risk assessment in collaboration with the United States Department of Agriculture's Food Safety and Inspection Service (FSIS), and in consultation with the Centers for Disease Control and Prevention (CDC). The purpose of this assessment is to systematically examine available scientific data and information in order to estimate the predicted relative risk of serious illness and death that may be associated with consumption of different types of ready-to-eat foods that may be contaminated with *Listeria monocytogenes*. This examination of current science and the models developed are among the tools that food safety regulatory agencies will use to evaluate the effectiveness of current policies, programs and regulatory practices that will minimize the public health impact of this pathogenic microorganism. This work provides a comprehensive assessment, building on and improving upon previously published assessments that related foodborne exposure to human listeriosis (Lindquist and Westöö, 2000, Buchanan *et al*., 1997; Farber *et al*., 1996; Haas *et al*., 1999; Hitchins, 1995 and 1996; and Teufel and Bendzulla, 1993).

DHHS/FDA and USDA/FSIS announced their intent to conduct a risk assessment of the public health impact of *Listeria monocytogenes* from food in the *Federal Register* (US DHHS, 1999a). At that time, the public was invited to comment on the planned assessment and submit scientific data and information for use in the assessment. The advice and recommendations of the National Advisory Committee on Microbiological Criteria for Foods (NACMCF) were sought on the assumptions and the risk assessment model structure to be used (US DHHS, 1999b, 1999c). During the conduct of this risk assessment, FDA and FSIS solicited the technical advice and opinions of scientific experts in various disciplines. In addition, critical review of this risk assessment model and a draft document was solicited and received from members of the Interagency Risk Assessment Consortium and other government employees.

This risk assessment was preceded by the Draft Assessment of Relative Risk to Public Health from Foodborne *Listeria monocytogenes* among Selected Categories of Ready-To-Eat Foods (DHHS/USDA, 2001). In January 2001, FDA and FSIS invited comments on the draft risk assessment. These comments, additional new data, and improved modeling techniques are incorporated into this revised version. A chronology of the technical and scientific review involved in the development of this *Listeria monocytogenes* risk assessment is provided in Appendix 1. A summary of the public comments submitted in response to the January 2001 draft risk assessment and our responses to these comments is provided in Appendix 2.

An international risk assessment on *Listeria monocytogenes* is concurrently being conducted by WHO/FAO for the Codex Alimantarius, Codex Committee on Food Hygiene (WHO/FAO, 2003). This FDA/FSIS risk assessment was conducted simultaneously with but independent of the WHO/FAO effort. The latter explored the dose-response relationship in more detail but determined the risks for only four representative foods. The conclusions reached in the WHO/FAO risk assessment are compatible with those reached in this FDA/FSIS risk assessment.

This risk assessment estimates the potential levels of consumer exposure to foodborne *Listeria monocytogenes* from different types of ready-to-eat (RTE) foods (including seafood, vegetables, fruit, dairy products, and meats), and characterizes the likely impact of this exposure on public health. Included is an evaluation of the impact of foodborne *Listeria monocytogenes* on the health of three age-based subpopulations, two of which are vulnerable groups that were distinguished based on FoodNet surveillance data.

- Perinatal: This subpopulation includes fetuses and neonates from 16 weeks after fertilization to 30 days postpartum. The neonatal cases are assumed to be pregnancy-associated cases where exposure occurs *in utero* as a result of foodborne *Listeria monocytogenes* infections of the mothers during pregnancy. Manifestations of listeriosis for this subpopulation group include spontaneous abortions, stillbirths, and neonatal infections.

- Elderly: This subpopulation includes individuals who are 60 or more years of age. This group is considered to have increased susceptibility to listeriosis due, in part, to physiological changes associated with the natural aging process.
- Intermediate-Age: Because there are insufficient data to separate the remaining population into discrete subpopulations, this group includes the remaining population, both healthy individuals (with very low risk of severe illness or death from *Listeria monocytogenes*) and certain susceptible subpopulations. The subpopulations include individuals with increased susceptibility to listeriosis; such as AIDS patients or individuals taking drugs that suppress the immune systems (*e. g.*, cancer or transplant drugs). Individuals within these subpopulations account for most of the cases of listeriosis within the intermediate-age group.

In addition, the number of predicted cases of listeriosis for the total United States population was estimated on a per serving and per annum basis for each food category.

Background

A series of illness outbreaks associated with the consumption of coleslaw, pasteurized milk, and fresh soft cheese in the early 1980s led to the recognition of *Listeria monocytogenes* as a foodborne pathogen.

In 1991, the NACMCF presented its analysis of the emerging problem and its recommendations to FSIS, FDA and other United States government agencies (NACMCF, 1991). The NACMCF recommended control strategies to minimize the presence, survival, and multiplication of *Listeria monocytogenes* in foods. These control strategies included the development of an effective surveillance system for listeriosis, targeted efforts on specific foods, and the use of HACCP-based (Hazard Analysis and Critical Control Points) programs to ensure the safety of foods from processing to consumption.

Major efforts by industry and regulatory agencies during the early 1990s reduced the incidence of listeriosis by approximately 50%. However, further reductions in illness are increasingly

difficult, in part because of the unique challenges associated with controlling this pathogen. Several barriers to its control include:

- The microorganism is commonly found in the environment, including food processing, distribution, and retail environments, in foods, and in the home.
- It primarily affects a small segment of the population that has heightened susceptibility.
- It can grow slowly in many foods during refrigerated storage.
- It is more resistant than most bacteria to the conditions and treatments used to control foodborne pathogens.

Current Policies

Based on the known characteristics of this microorganism and the disease, FDA maintains a policy of "zero-tolerance" for *Listeria monocytogenes* in ready-to-eat foods (i.e., products that may be consumed without any further cooking or reheating). This means that the detection of any *Listeria monocytogenes* in either of two 25-gram samples of a food renders the food adulterated as defined by the Federal Food, Drug, and Cosmetic Act, 21 U.S.C. 342(a)(1) (Shank *et al*., 1996). This policy was affirmed in the 1995 United States District court decision, United States v. Union Cheese Co. (Anonymous, 1995).

FSIS's "zero-tolerance" policy applies to the detection of *Listeria monocytogenes* in ready-to-eat products. If meat or poultry products are contaminated with *Listeria monocytogenes*, the products are adulterated under the provisions of the Federal Meat Inspection Act and the Poultry Inspection Act, 21 U.S.C. 601(m) or 453 (g), respectively (Anonymous, 1994).

Other countries, including some major trading partners of the United States, have different policies for dealing with *Listeria monocytogenes* contamination. Countries such as Canada and Denmark have a "non-zero tolerance" for *Listeria monocytogenes* for some classes of foods (Health Canada, 1994). For example, in Canada, ready-to-eat (RTE) foods that have not been associated with an outbreak and do not allow any growth of *Listeria monocytogenes* during a 10-day period of refrigerated storage, may contain up to 100 *Listeria monocytogenes* organisms per

gram of food (Health Canada, 1994). Denmark has six classes of foods with various criteria for *Listeria monocytogenes*. In raw RTE foods, for example, two of five samples can contain between 10 and 100 organisms per gram, but no sample can exceed 100 organisms per gram.

There is no epidemiological evidence that demonstrates whether a zero or non-zero tolerance policy leads to a greater rate of listeriosis. Estimates of disease rates between different countries must be considered with caution because of different surveillance and reporting systems but the comparable overall rates of listeriosis for ranges from 0.1 to 11.3 cases per million persons per year in Europe, 3.4 to 4.4 cases per million people per year in the United States, and 3 cases per million per year in Australia (WHO/FAO, 2003).

Healthy People 2010 Initiative

The commitment of FDA, FSIS, and CDC to reduce foodborne listeriosis was formally reaffirmed as a national public health goal in the Healthy People 2010 initiative coordinated by the United States Department of Health and Human Services (US DHHS). The federal government established a goal of working with industry, public health, and research communities to achieve an additional 50% reduction in listeriosis by 2010. "Healthy People" is a national health promotion and disease prevention initiative that brings together national, state, and local government agencies; nonprofit, voluntary, and professional organizations; and businesses, communities, and individuals to improve the health of all Americans, eliminate disparities in health, and improve years and quality of healthy life (US DHHS, 2000).

Preliminary FoodNet data on the incidence of foodborne illnesses for the United States in 2001 indicated that the incidence of infection from *Listeria monocytogenes* decreased between 1996 and 2001 from 0.5 to 0.3 cases per 100,000 people per year. The level then reached a plateau. In order to reduce further the incidence to a level of 0.25 cases per 100,000 people by the end of 2005, it became evident that additional targeted measures were needed. The *Listeria monocytogenes* risk assessment was initiated as an evaluation tool in support of this goal.

Risk Assessment Overview

This risk assessment follows the risk assessment structure of the Joint Food and Agriculture Organization/World Health Organization Expert Consultation on the Application of Risk Analysis to Food Standards Issues (Joint FAO/WHO, 1995). The structure consists of four components: (1) hazard identification, (2) exposure assessment, (3) hazard characterization, and (4) risk characterization. Hazard identification is defined by the Joint FAO/WHO Consultation as the identification of known or potential health effects associated with a particular biological, chemical, or physical agent. Exposure assessment is the qualitative and/or quantitative evaluation of the degree of intake likely to occur. Hazard characterization is the qualitative and/or quantitative evaluation of the nature of the adverse effects associated with biological, chemical, and physical agents that may be present in food. Finally, risk characterization is the integration of hazard identification, hazard characterization, and exposure assessment into an estimation of the adverse effects likely to occur in a given subpopulation, including attendant uncertainties.

Microbiological risk assessments generally use the same conceptual framework developed for chemical risk assessments (ICMSF, 1994). However, while there are many similarities between chemical and microbial risk assessments, there are also differences. At this time, the major concern with microbiological hazards is an acute illness from a single exposure, rather than illness from a low level, chronic exposure. Even so, sequelae and other long-term effects are beginning to be recognized for some microorganisms, but knowledge is still limited in this area. In this microbial risk assessment, the infectious unit is a single microorganism. Low levels of microorganisms (rather than low concentrations of a chemical substance) characterize the frequent exposure with higher levels of exposure occurring only occasionally. While the likelihood of disease increases with increasing numbers of pathogenic microorganisms consumed, the potential for low levels of infectious agents to cause disease cannot be dismissed. Another difference between microbial and chemical hazards is that the level of a microorganism in a food can change, while chemical concentrations usually remain constant. This change in microbial levels should be accounted for in a microbial risk assessment's model. Human exposure levels to a pathogen in a food can rapidly increase by a million-fold within even a

relatively short period of temperature abuse. Conversely, heating food immediately before consumption can reduce pathogen levels to a negligible risk. These biological characteristics of bacteria require the inclusion of detailed modeling steps in the exposure assessment. There is usually little question as to the hazard of microbial pathogens, although the dose-response relationships may not be easily described.

Figure I-1 shows the organization of this report including the main components of each chapter such as types of data and modeling techniques described. Additional details concerning the structure and modeling techniques used in this risk assessment are provided in Appendix 3.

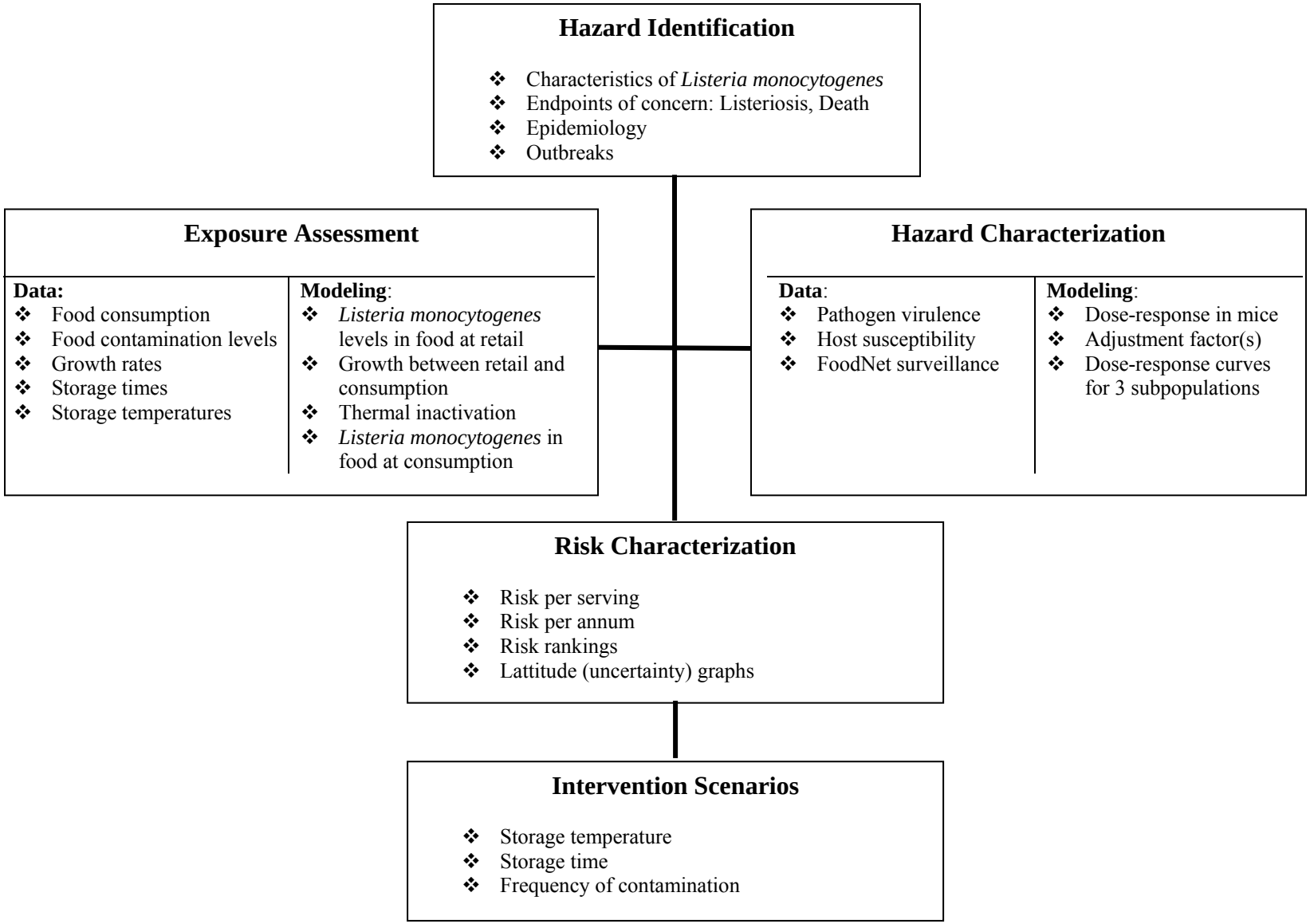

Figure I-1. Overview of *Listeria monocytogenes* Risk Assessment Document