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Microarray Detection and Characterization of Bacterial Foodborne Pathogens

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Chapter 1
Introduction to Foodborne Diseases

Abstract Death and disease caused by food lacking safety guarantees represent a continuing threat to worldwide public health and socioeconomic development. Recent large outbreaks of foodborne infections have alerted us to the possible increase in the incidence of foodborne diseases. The epidemiology of these diseases has changed in recent decades, not only due to the emergence of new pathogens but also due to changes that have occurred in the food supply, including changes in processing and consumer preference and a global marketplace, and by the increase in populations with greater susceptibility to these diseases. Epidemiological surveillance, research into new problems, and collaboration among the different professional groups to put measures for controlling foodborne diseases into practice are the main strategies that are becoming increasingly necessary. The possibilities offered by modern tools and molecular techniques have greatly expanded the options available for monitoring undesirable microorganisms in the food supply chain and for quickly implementing appropriate measures as a result of the rapid detection and characterization of pathogens.

Keywords Food safety • Foodborne infections • Outbreaks of foodborne illness • Emerging pathogens • Foodborne disease surveillance • Foodborne disease control

1.1 Foodborne Diseases Remain a Significant Cause of Morbidity and Mortality

Death and disease caused by food lacking safety guarantees represent a continuing threat to worldwide public health and socioeconomic development. Humans acquire infections from a large variety of sources and by various transmission routes. Most foodborne diseases are mild and are associated with acute gastrointestinal symptoms, such as diarrhea and vomiting. In some cases, however, foodborne diseases

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can be more severe and may even be life-threatening, especially in children in developing countries. These diseases may also cause chronic sequelae and disabilities (Blackburn and McClure 2009).

The true extent of the cost of all types of foodborne diseases associated with microorganisms (bacteria, viruses, and parasites) is not precisely known, but it is thought to be enormous (Kuchenmüller et al. 2009; Newell et al. 2010). Despite the enormous effort in recent decades to prevent and control foodborne diseases, people in both industrialized and developing countries continue to suffer from them in large numbers. In the United States alone, the cost incurred by foodborne diseases in 2007 was estimated to be between $357 billion and $1.4 trillion (Roberts 2007). Developing countries tend to suffer from the largest share of the burden of foodborne diseases. The World Health Organization (WHO 2011) estimates that foodborne and waterborne diarrheal diseases kill about 2.2 million people annually, 1.9 million of them children. In addition to reducing the financial costs, public health spending will reduce morbidity and mortality associated with these diseases. It has been estimated that increasing the supply of rural health care by 65% in developing countries could save 1.2 million lives annually (Green et al. 2009).

1.2 Current Trends in Foodborne Diseases

Data on current trends in foodborne diseases are limited to a few industrialized countries and a surprisingly small number of pathogens (Blackburn and McClure 2009; Ammon and Makela 2010; Newell et al. 2010). Despite having better information systems than other regions, statistics on foodborne diseases in the US and some European countries are overly dominated by cases of salmonellosis and campylobacteriosis. In contrast, the statistics in other regions depend almost exclusively on information about disease outbreaks, with the result being that ultimately other microorganisms are identified as the main causes of these diseases.

Epidemiological surveillance and control of foodborne viral pathogens are usually scarce. In Western countries, noroviruses and hepatitis A virus are the main human foodborne pathogens in terms of the number of outbreaks and people affected. Most foodborne viral infections originate from infected people who handle food that is not subsequently heated or otherwise treated (Koopmans and Duizer 2004).

There are many known foodborne pathogenic parasites, such as *Ascaris*, *Cryptosporidium,* and *Trichinella*, but their presence in food, livestock, and the environment is often not investigated. This results in a lack of information about the epidemiology of parasite contamination throughout the food supply chain (Newell et al. 2010). According to the Centers for Disease Control and Prevention (CDC 2011), *Cryptosporidium* is reported to be one of the leading causes of laboratory-confirmed foodborne infections in the United States.

The main foodborne bacterial pathogens are *Salmonella*, *Campylobacter*, *Yersinia*, Shiga-toxin- (Stx) producing *Escherichia coli* (STEC) and *Listeria monocytogenes*. Antibiotic resistance is also a significant issue with some foodborne

pathogenic bacteria (*Salmonella*, *Campylobacter*, *Shigella*, *Vibrio*, *Staphylococcus aureus*, *E. coli,* and *Enterococcus*). In 2009, campylobacteriosis, salmonellosis, and yersiniosis were the most frequent foodborne zoonotic infections in humans in the EU (Lahuerta et al. 2011). Infections due to *Salmonella* were the most common in the US and were associated with the highest number of hospitalizations and deaths among all foodborne diseases. *Campylobacter*, *Shigella*, and STEC O157:H7 are also leading causes of bacterial foodborne infections in the United States (CDC 2011).

According to the European Food Safety Authority (EFSA 2011), in the EU most of the 5,550 confirmed outbreaks of foodborne diseases were caused by *Salmonella*, viruses, and bacterial toxins. The foods most frequently involved were eggs, buffet-style meals, and pork. In an analysis of foodborne disease outbreak data to estimate the proportion of human cases of specific enteric diseases attributable to a specific food item, Greig and Ravel (2009) found that a few etiologies were very specifically associated with some foods. *Salmonella* Enteritidis outbreaks occurred relatively often in the EU, with eggs from laying hens the most common source (Pires et al. 2011). Detailed analysis of different regions highlighted some special features: *Campylobacter*-associated outbreaks were mainly related to poultry products in the EU and to dairy products in the US (Greig and Ravel 2009). STEC in cattle and beef and *Yersinia* in pigs and pork also represent significant associations between zoonotic infections and food in the EU (EFSA 2011). Also among the main concerns and challenges for food safety and hygiene are *L. monocytogenes* in ready-to-eat (RTE) processed food, and viral pathogens at food establishments (Sofos and Geornaras 2010).

Recent large outbreaks of foodborne infections have alerted us to the possible increase in recent years in the incidence of foodborne diseases. However, 2010 statistics from the US on the incidence of six significant foodborne pathogens show no significant changes when compared to the period 2006–2008. Only the infection rates for *Shigella* and STEC O157:H7 show significant declines, while those of *Vibrio* show significant increases (CDC 2011). In some cases, increased awareness about food safety, changes in legislation and educational measures, as well as changes in food production practices (e.g., effective control measures for animal reservoirs) have produced declines in the incidence of certain foodborne diseases in some regions (Blackburn and McClure 2009). For example, in 2009 the EU confirmed the declining trend in the number of salmonellosis cases in humans, with statistically significant figures (EFSA 2011). Campylobacteriosis represents the most frequent zoonosis in the EU (EFSA 2011), and *Campylobacter* spp. represents the main cause of sporadic bacterial gastroenteritis worldwide. However, in some countries the number of cases of campylobacteriosis seems to have stabilized or declined, and it has been suggested that this decline may be due to the implementation of the Hazard Analysis and Critical Control Point (HACCP) system in poultry industries (CDC 2011). In the case of listeriosis, a decline in the number of cases was also observed toward the end of the twentieth century. This has been linked to efforts carried out by food processing companies and food regulatory agencies to control *L. monocytogenes* in high-risk foods (Swaminathan and Gerner-Smidt 2007). However, there is currently growing concern about the increase in listeriosis