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Reflections on a Career in Public Health: Evolving Foodborne Pathogens, Environmental Health, and Food Safety Programs

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Abstract

Events affecting environmental health and food safety policy, programs and organization and emerging or identified foodborne diseases are reviewed by decade. The review starts with the impact of the 1940s war years on environmental sanitation, as it was called, and disease control. It continues with the intensifying disease surveillance and improvements in sanitation of the 1950s and the improvements in foodborne-disease surveillance and the reorganization of environmental programs of the 1960s. Many previously unknown foodborne pathogens were identified, and more changes in environmental policy came about in the 1970s. Evaluation of foodborne-disease control measures were initiated. In the 1980s, evaluation of major foodborne-disease problems came to the forefront. In the 1990s, the media and consumer groups became aware of foodborne-disease problems and concerned with the environment. The first decade of the 21st century will be faced with continuing dilemmas posed by emerging diseases and will need to provide solutions through the balancing of science, education, and politics.

Introduction

This paper reflects on a career in public health, revealing events that led to an understanding of foodborne diseases, their prevention, and the rationale for present policies that address them. This review is presented by decade and considers activities of the Public Health Service and the World Health Organization, national environmental health policy, emerging foodborne pathogens, the impact of foodborne-disease outbreaks, and measures to prevent and control foodborne diseases.

1940s–Impact of World War II on Public Health

The Public Health Service and Environmental Health

During the war years, the Public Health Service (PHS) broadened the Commissioned Corps, authorizing the commissioning of nurses, scientists, veterinarians, dieticians, physical therapists, and sanitarians. A Malaria Control in Wartime Areas (MCWA) program was initiated because malaria was endemic in the southern United States and posed a problem for the training of troops in the region. Massive efforts of swamp drainage and larviciding, which were done by and with the leadership of engineers, scientists, and sanitarians, eliminated the disease. This agency then took on typhus control, which revolved around rodent and flea control. MCWA was also successful in eradicating this disease from the United States. The reporting of milkborne-disease outbreaks, which had begun in 1923, and of foodborne-disease outbreaks, which had begun in 1938, continued to be done by the Division of Sanitary Engineering Services of PHS. This division published the first model ordinance and code for eating and drinking establishments. The ordinance and

code was a model for state and local health departments to adopt (Division of Sanitary Engineering Services, 1943).

Following World War II, PHS formed the Communicable Disease Center (CDC) from the very successful MCWA that was headquartered in Atlanta. Divisions of the Center included Laboratory, Technology, and Training. Training centers, which emphasized training in environmental sanitation and directed it primarily at sanitarians, were established in several locations (e.g., Colorado, Georgia, Kansas, New England, New York, Pennsylvania, and Washington). The philosophy of this training was "Learn by Doing." Twelve-week field-oriented training courses on environmental sanitation (including communicable diseases, water, sewerage, waste disposal, insect and rodent control, milk, food, environmental surveys, and related topics) and specialized short courses on environmental sanitation subjects were featured. Also at this time, nationally, PHS promoted short-course training of food service workers by demonstrations, film strips, and training materials. Septic-tank research was being done at the Robert A. Taft Sanitary Engineering Center in Cincinnati.

(Although the term "environmental health" may have been used by some during this time, the commonly used term was "environmental sanitation.")

Foodborne Diseases

In the 1940s and before, textbooks on food sanitation and microbiology were usually limited to descriptions of botulism, staphylococcal food poisoning, salmonellosis, trichinosis, and tapeworm infestations. There were a few texts specifically on food poisoning that had expanded descriptions of these hazards and covered a little more, such as chemical poisonings and plant toxicants. During this decade, accounts of *Clostridium perfringens (welchii)* appeared in the scientific literature (Knox & MacDonald, 1943).

(Programs dealing with foods were called "food sanitation" in the United States. They were called "food hygiene" in European countries and by international agencies.)

1950s–The Intensifying of Disease Surveillance and Continued Improvements in Sanitation

The Public Health Service and Environmental Health

At CDC, the Epidemic Intelligence Service (EIS) and an Epidemiology Division were formed. With knowledge of epidemiology and statistics, epidemics could be detected and investigated more effectively than in the past. Trained EIS officers were mostly stationed in states near the source of potential outbreaks. CDC's field training stations flourished in the early years of the decade and trained many sanitarians who subsequently became leaders in the field. This activity, however, declined at the end of the decade. A mobile unit demonstrated pasteurization tests and controls across the country.

Environmental health activities gained increasing recognition within PHS, nationally and internationally. Many PHS sanitarians and engineers served assignments in developing countries. Native American health responsibilities were transferred to the PHS. This initiated large-scale campaigns of hospital building and construction of water supplies and waste disposal systems in Native-American communities. Responsibility for reporting foodborne-disease outbreaks was transferred to the National Office of Vital Statistics, and an annual summary was given in the Public Health Report. PHS's Milk and Food program published a recommended vending-machine-sanitation ordinance (Division of Sanitary Engineering Services, 1957). The National Association of Sanitarians (now the National Environmental Health Association [NEHA]) initiated a certification of registration for sanitarians.

Foodborne Diseases

In the 1950s, early descriptions of *Bacillus cereus* gastroenteritis were cited in the scientific literature (Hauge, 1950). The first edition of *Procedures for the Investigation of Foodborne Disease Outbreaks* (Helvig et al., 1957) was published by the International Association of Milk, Food and Environmental Sanitarians (IAMFES). This manual provided guidance to sanitarians and others for outbreak investigations.

1960s–Improved Foodborne-Disease Surveillance and Reorganization of Environmental Programs

The Public Health Service and Environmental Health

The Communicable Disease Center (CDC) stimulated interest in salmonellosis by holding a national/international conference on the subject and by other means (Communicable Disease Center, 1964). The responsibility for publication of morbidity and mortality data, including foodborne diseases, was transferred from the National Office of Vital Statistics to CDC, (now known as the Centers for Disease Control and Prevention in 1961). A *Salmonella* Surveillance activity and monthly reports were initiated in April 1966 with eight states participating; all states were participating by the end of the year. This undertaking was stimulated by a few nationwide outbreaks of salmonellosis. One outbreak affecting infants was caused by *Salmonella newbrunswick* that was traced to a nonfat-dry-milk product (Collins et al., 1968). Because of this report, the Food and Drug Administration (FDA) initiated an extensive testing program for dry-food products and ingredients. Salmonellae were often found. *Salmonella* was considered as an adulterant, and any product under FDA's jurisdiction that contained it had to be removed from the market. This was quite a change from the previous emphasis on filth, chemical, and pest contamination of foods. During this decade, surveillance activities and reports were issued on many other pathogens that could be foodborne (e.g., *Shigella*, *Brucella*, *Trichinella*, and hepatitis viruses). This was a period in which significant information about the foodborne pathogens was generated from outbreak investigations and research and widely distributed.

In 1961, authority for water pollution was transferred from PHS, and a Federal Water Pollution Control Administration was established, which was moved to the Department of Interior along with many PHS engineers. The CDC field stations and 12-week courses on environmental sanitation were terminated and replaced by short courses on epidemiology, foodborne-disease prevention, and other disease-related topics. These courses were given at CDC headquarters and at various locations throughout the country and territories. The Milk and Food program of PHS issued a revised model food service ordinance in 1962 (Division of Environmental Engineering and Food Protection, 1962), and a revised vending ordinance three years later (Division of Environmental Engineering and Food Protection, 1965). In 1968, FDA was transferred into PHS, while the retail-food, interstate-carrier, shellfish, milk, food research and food sanitation training activities of PHS were put into divisions of FDA. These actions further diminished the role of CDC in providing training in environmental and food issues, other than those that dealt with epidemiology of foodborne diseases and their control.

The Soviets put a satellite, called "Sputnik," into space. Because of cold-war competition, this nation consequently made an all-out effort to beat the Soviets to the moon. As a part of the manned mission to the moon, the hazard analysis critical control point (HACCP) concept evolved and was used to ensure that foods manufactured for astronauts were safe.

Foodborne Diseases and Their Control

In the 1960s, *Vibrio parahaemolyticus* was shown to be foodborne (Fujino et al., 1953), and when coastal waters were tested for this bacterium, it was found in warm waters throughout the world. Hepatitis A was epidemiologically associated with the ingestion of raw oysters (Mason & McLean, 1962). Within the next few years, many hepatitis A outbreaks were traced to sewage-contaminated shellfish-harvesting waters and to foods contaminated by infected persons. Aflatoxins were discovered (Sargeant, Sheridan, O'Kelly, & Carnaghan, 1961). The discovery initiated study of these and other mycotoxins, which constitute a group of unrelated fungal metabolites that can induce a variety of toxic responses (including liver cancer) in humans and other animals. In 1963, the incidence of botulism increased fourfold. A part of this increase was due to an outbreak of type-E botulism from commercially vacuum-packed whitefish resulting in 17 cases and five deaths (Communicable Disease Center, 1963). Other botulism outbreaks were associated with commercially processed foods, which shattered the complacency that had set in about commercial operations. Publicity about the incidents alerted the public and caused economic damage to segments of the food industry. PHS rapidly held a symposium of experts on botulism, which stimulated action by governmental agencies and industry to conduct research, develop preventive measures, and re-emphasize retort controls (Lewis & Cassel, 1964). The National Research Council sponsored an evaluation of the *Salmonella* problem (Committee on *Salmonella*, 1969). Recommendations dealt with contamination of raw animal products and drinking water; contamination of processed foods, feeds, and drugs; mishandling of foods during preparation and serving; education and training; and research. A second edition of the IAMFES manual on outbreak investigation was issued in 1966 (Hendricks et al., 1966). A brief listing of the factors that contribute to foodborne-disease outbreaks was cited in 1969 (Bryan, 1969), but the data were not quantified.

(The term "food protection" began replacing "food sanitation" toward the end of the decade.)

1970s–More Emerging Foodborne Pathogens and Evaluation of Their Control, and More Changes in Environmental Policy

The Public Health Service, International and Environmental Health

In 1970, the U.S. Environmental Protection Agency (U.S. EPA) was created, and air pollution, solid waste, pesticide, drinking water, and some aspects of radiological health programs were transferred from the PHS. This step weakened linkage between human disease and the environment while accentuating the regulatory role of government for environmental matters. Legislation also created the National Institute of Occupational Safety and Health (NIOSH) in the PHS (CDC) and the Occupational Safety and Health Administration (OSHA) in the Department of Labor. In 1972, PHS was reorganized into three agencies—the National Institutes of Health, the Food and Drug Administration, and the rest of PHS.

Annual reviews of the incidence of foodborne-disease outbreaks were issued by CDC during this decade. In 1976, FDA's Division of Retail Food Protection FDA published a revised model food service ordinance and two years later a vending machine ordinance (Division of Retail Food Protection, 1976, 1978). The International Commission on Microbiological Specifications for Foods wrote a book on food sampling and specifications. The book was targeted for food commodities in international trade (International Commission on Microbiological Specifications for Foods [ICMSF], 1974).

An outbreak of *Salmonella eastbourne* gastroenteritis that occurred in 23 states and eight Canadian provinces was traced to contaminated chocolate (Craven et al., 1975). The median age of the victims was three years, but all age groups were affected. Chocolate was an unexpected vehicle, but salmonellae can survive high temperatures and long storage in low-water-activity products of this kind. FDA and its Canadian counterpart initiated recalls of the product.

Precooked roast beef was implicated as a vehicle in an outbreak due to *Salmonella newport* (Checko et al., 1977). More than 200 people were affected. This and similar outbreaks stimulated the U.S. Department of Agriculture (USDA) to sponsor research on cooking roast beef and, on the basis of the research, to develop cooking standards for roast beef (Goodfellow & Brown, 1978). Roast beef was also a common vehicle in outbreaks traced to preparation and holding in food service establishments. Hazards were detected during hazard analyses of roast beef operations and control measures recommended (Bryan & Kilpatrick, 1971; Bryan & McKinley, 1979, 1980).

Foodborne Diseases and Their Control

Campylobacter, Yersinia, Listeria, Vibrio vulnificus, Toxoplasma, non-O1 vibrios, and Norwalk-like viruses were identified as foodborne in the 1970s (Blake & Weaver, 1980; Bryan, 1979a; Jacobs, 1973; Kapikian et al., 1972). *Campylobacter* was identified as the leading cause of gastroenteritis in many countries. A compilation of foodborne diseases and related information was developed and updated annually during this decade; it contained a list of approximately 200 diseases that can be foodborne (Bryan, 1970).

The first National Conference on Food Protection was held in Denver in 1971 (Kupchik, Elston, Lewis, & Hoover, 1971). Task forces evaluated and made recommendations about 10 issues. Significant among these discussions was the presentation of the HACCP approach to those not involved with the National Aeronautics and Space Administration and recommendations for training food service managers rather than workers. In 1974, the first symposium on the HACCP concept was presented at a meeting of the Institute of Food Technologists (Bauman, 1974; Bryan, 1974b; Ito, 1974; Peterson & Gunnerson, 1974). Following a couple outbreaks of botulism from commercially canned products, FDA initiated a joint FDA/industry training program (Pillsbury Company, 1973) and a mandatory HACCP program for low-acid canned foods. With the aid of grants, several states and food service groups experimented in developing training courses for food service managers. The National Institute for the Foodservice Industry (later called the Education Foundation of the National Restaurant Association) took over leadership in this training endeavor with its *Applied Foodservice Sanitation* text (National Institute for the Foodservice Industry, 1974) and related training programs. Since then, hundreds of thousands of food service managers and workers have been trained in this program. Industry's

acceptance of responsibility in this endeavor was impressive, but many health agencies that had conducted this sort of training in the past decreased or relinquished their activities. Thus, they decreased the focus on education. A third edition of the manual *Procedures to Investigate Foodborne Illness* (Bryan et al., 1976), and a companion manual on waterborne-disease investigations (Bryan et al., 1979) were published.

Critical evaluation of outbreak reports gave rank and prevalence of specific factors that contributed to foodborne-disease outbreaks in 1972, 1974, and 1978 (Bryan, 1972; Bryan, 1974a; Bryan, 1978). These factors were presented in an inspection-form format (Bryan, 1974a; Bryan, 1979b). The data were compared over different review periods, and the ranking of the factors remained remarkably similar. The data also were classified for food service establishments, food-processing plants, and homes, which showed some variation in ranking of the factors; nevertheless, the same factors were evident. Of particular significance was that these data showed lack of cooling of cooked foods and improper cooling to be the leading contributing factor in foodborne disease. Contamination often was attributable to raw incoming foods, bare-hand contact with cooked foods, and cross-contamination from raw to cooked products. Insufficient cooking and reheating allowed pathogens to survive. It was also pointed out that many items commonly observed and checked as deficiencies on inspection forms during routine inspections were insignificant contributing factors.

Hazard analyses were done for many foods in numerous food service establishments of various types in this country during the 1970s and the next two decades (Bryan, 1981a; Bryan, 1981b). These analyses covered foods such as roast beef (Bryan & Kilpatrick, 1971; Bryan & McKinley, 1979); turkey (Bryan & McKinley, 1974; Bryan, McKinley, & Mixson, 1971); and chicken. Establishments at which these hazard analyses were made included school lunch kitchens and commissaries (Bryan & McKinley, 1974; Bryan et al., 1971); senior-meal central and satellite kitchens; meal-on-wheel delivery; fast-food (Bryan & Kilpatrick, 1971) and table-service restaurants; cafeterias; hospitals (Bryan & Lyon, 1984); airline caterers (Bryan, Seabolt, Peterson, & Roberts, 1978); soup and salad bars; and food markets (Bryan, 1989). The hazard analyses were done from the time of opening to closing and often on multiple successive days in each establishment and in multiple establishments for each type of establishment and food. With this approach, typical mishandling and mistreatment of foods were repeatedly detected. Many of the hazard analysis data and preventive measures are published in the scientific and technical literature; others have been used to set up HACCP systems for food companies and chains.

Microbiological surveys were done of foods prepared by vendors, in small food shops, and in hotels in Egypt (El-Sherbeeny, Saddik, Aly, & Bryan, 1985; El-Sherbeeny, Saddik, & Bryan, 1985; Saddik, El-Sherbeeny, & Bryan, 1985; Saddik, El-Sherbeeny, Mousa, El-Akkad, & Bryan, 1985; Saddik, El-Sherbeeny, & Bryan, 1986) under a joint CDC/Ministry of Health in Egypt project. Large populations of foodborne pathogens and indicator organisms were found. Holding at warm indoor and outdoor temperatures promoted bacterial growth.

The data were, of course, product and operation specific, but hazardous cooling procedures were identified for many foods in most types of establishments. In some kitchens, cooked foods were kept at ambient room temperatures for several hours and sometimes overnight. Slow cooling and associated microbial growth were identified repeatedly for many foods and in most facilities. Large cuts of meat, turkeys, rice, beans, pasta, large volumes of thick soups, and other foods cool slowly. In addition, time-temperature exposures during cooking were often insufficient to kill vegetative forms of common foodborne pathogens, particularly in many meat and poultry items and wrapped foods. Hot-holding temperatures varied, but sometimes situations were identified that would have incubated bacteria and led to generation of large populations of them, including foodborne pathogens. The potential for post-cooking contamination and cross-contamination was obvious in many operations. Pathogen contamination during bare-hand handling and from equipment used to process raw and cooked foods was documented by sampling and laboratory testing. Temperatures attained during reheating often did not meet code requirements. These practices were identified as the major events or factors that contribute to foodborne illness (Bryan, 1972, 1974b, 1978, 1988a, 1988b).

1980s–Evaluation of Major Foodborne Disease Problems

The>Public Health Service, International and Environmental Health

Acquired Immunodeficiency Syndrome (AIDS) was identified as a new disease of humans. Its cause and much about its etiology and epidemiology were learned. This deadly affliction renewed the focus on communicable diseases. Environmental health activities were assembled into a Center of Environmental Health at the Centers for Disease Control. This center was different from traditional environmental health programs in that it consisted of a Chronic Diseases Division and a Clinical Chemistry Division. The former included activities related to birth defects, cancer, special projects (e.g., agent orange), and special studies, as well as environmental affairs and the National Park Service. The latter included biochemical and toxicological laboratories. Toxic Substances and Smoking and Health programs were established at CDC.

Microbiological criteria for ground meats that had been established by the Oregon Department of Agriculture were challenged by the food industry and many food scientists. As a result, a committee of the National Research Council (NRC) was established to study the issue. After five years of reviewing the situation and the scientific literature, NRC issued a report on the evaluation of microbiological criteria for foods (Subcommittee on Microbiological Criteria, Committee on Food Protection, Food and Nutrition Board, National Research Council, 1985). The report emphasized control at the source and embraced the HACCP approach rather than end-product testing.

Foodborne- and waterborne-disease outbreaks were identified on cruise ships, and when epidemics occurred, CDC put teams on board to investigate the situations. A surveillance-and-inspection activity was initiated for these ships.

FDA intensified attention to milk and dairy product operations following a major outbreak (briefly described below), and many deficiencies in dairy equipment and operation were identified. Several recalls of dairy products were made, costing the industry millions of dollars. Cooking criteria for roast beef were specified by FDA in a sanitation code for retail food (Division of Retail Food Protection, 1982).

In 1984, the World Health Organization (WHO) and the Food and Agricultural Organization of the United Nations (FAO)

released an expert-committee report on food safety (FAO/WHO Expert Committee on Food Safety, 1984). The report recognized that prevention and control of foodborne diseases are based on a) avoiding or minimizing contamination, b) destroying or denaturing the contaminant, and c) preventing further spread or multiplication of contaminants. Emphasis was put on biological problems. Recommendations called for improved program coordination, development of laboratories, training of food workers, education of the public, the HACCP approach, and improved surveillance and research. WHO also issued reports on health education in food safety (WHO, 1988) and health surveillance for food-handling personnel (WHO, 1989). The International Commission on Microbiological Specifications for Foods (ICMSF) made recommendations to WHO on control of salmonellosis and recommendations about use of the HACCP approach in developing countries (WHO/ICMSF, 1982; ICMSF, 1986b; Simonsen et al., 1987). The former set of recommendations gave examples of critical control points for many products in international trade, and the latter set down basic principles of the HACCP approach. In addition, ICMSF wrote a two-volume book on microbiological ecology of foods (ICMSF, 1980a, 1980b) and the first book on the HACCP approach (ICMSF, 1988). It also revised the sampling book (ICMSF, 1986a).

Hazard analyses of home-prepared foods were done under the sponsorship of WHO in Peru (locations included shanty towns in a dry region on the outskirts of a large urban area, huts in the high Andes, and shacks and villages along the Amazon River) (Bryan, Michanie, Alvarez, & Paniagua, 1988; Bryan, Michanie, Mendoza et al., 1988; Bryan, Michanie, Moscos Vizcarra, et al., 1988; Michanie, Bryan, Alvarez, Barros Olivo, & Paniagua, 1988; Michanie, Bryan, Mendoza Fernandez, et al., 1988); and the Dominican Republic (Michanie, Bryan, Alvarez, & Barros Olivo, 1987; Michanie, Bryan, et al., 1988). FAO sponsored a similar project in Thailand (Bryan, Phithakpol, Varanyanond, Wongkhalaung, & Auttaviboonkul, 1986). Hazard analyses of street-vended foods were done in the Dominican Republic (Bryan, Michanie, Alvarez, & Paniagua, 1988). High levels of indicator organisms were identified in many of these foods, and foodborne pathogens were found in some.

Foodborne Diseases and Their Control

In the 1980s, *Escherichia coli* was epidemiologically linked to hamburgers sold by a popular fast-food chain in two widely separated states, but this discovery did not attract much national attention (Riley et al., 1983). An outbreak of salmonellosis traced to milk, however, attracted considerable attention from the public and the press (Ryan et al., 1987). There were 16,000 or more laboratory-confirmed cases and an estimated 200,000 cases. This was the largest foodborne outbreak in history. The milk had been pasteurized in one of the nation's largest and most modern dairy plants. Either pasteurization had failed or post-process contamination had occurred.

Shortly afterward, nearly 150 cases of listeriosis and 47 deaths (many infants and aborted fetuses) were caused by a soft cheese (Linnan et al., 1988). A court case followed, and the owner and manager of the cheese plant were found guilty of felonies and given jail sentences. These outbreaks prompted testing programs by FDA and research on *Listeria*. *Listeria monocytogenes* was commonly isolated from all sorts of foods. The two outbreaks stimulated implementation of HACCP systems in many processing plants.

From the mid-1970s to the mid-1980s, *Salmonella enteritidis* infections increased sixfold in the northeastern United States (St. Louis et al., 1988). From the mid- to late 1980s, scores of foodborne outbreaks caused by *S. enteritidis* were reported in the Northeast. The vehicle was identified as Grade A shell eggs or foods that contained eggs. These outbreaks stimulated actions by FDA and USDA, as well as state and other food regulatory agencies, to increase surveillance of egg production and processing and to initiate traceback investigations to identify farms where *S. enteritidis* existed.

During this decade, television networks began including food operations in their investigative-reporting programs. This reporting pointed out that poultry is commonly contaminated with salmonellae. Food contamination and foodborne-disease outbreaks became news. Congressional hearings followed.

In 1981, information on factors that contributed to foodborne-disease outbreaks was used as a part of hazard analyses (Bryan, 1981a, 1981b). This information was classified under incubation, process failure, and contamination categories and presented in a format for a hazard analysis report, which included a flow diagram and specific hazard check sheets. It was also presented in the format of a HACCP work sheet (including hazards, critical control points, preventive measures, and monitoring procedures) and as a part of a 1982 National Research Council publication on the microbiological safety of foods in feeding systems (Bryan, 1982c). Also, that year, the data were used in developing a risk assessment for food service establishments in a community (Bryan, 1982b). This assessment combined coefficients about food vehicles, operational hazards based on disease contributory factors, and volume prepared. Newer data on contributory factors were evaluated and presented in a revised format in 1988 (Bryan, 1988a). The data were broken down for specific foodborne diseases and for mishandling in food service, process, and home operations. When the data were compared over time, the results were again similar. Data from analyses undertaken with similar approaches in England and Wales (Roberts, 1982), Canada (Todd, 1983), Australia (Davey, 1985), and New York State (Weingold, Guzewich, & Fudala, 1994) have shown similar results. The fourth edition of the IAMFES foodborne-disease-outbreak investigation manual (Bryan et al., 1987) was issued, and a manual on investigation of vectorborne diseases was published (Bryan et al., 1983). Major revisions were made to the compendium on foodborne diseases, and the manual was reissued (Bryan, 1982a).

Hazard analyses were continued in food service establishments. Data were obtained on *au jus* (Bryan & McKinley, 1980); rice (Bryan, Bartleson, & Christopherson, 1981) and other Chinese foods (Bryan, Bartleson, Sugi, Miyashiro, & Tsutsumi, 1982; Bryan, Bartleson, Sugi, Sakai, et al., 1982; Bryan, Sugi, Miyashiro, et al., 1982); beans and other Mexican foods (Bryan & Bartleson, 1985); covered-pit-cooked pig and other Hawaiian foods (Bryan, Matsuura, Sugi, et al., 1982); gyros (Bryan, Standley, & Henderson, 1980); hamburgers and barbecued meats (Bryan, McNaught, & Blehm, 1980); seafoods and frozen meal packs (Bryan, Smith, & McKinley, 1980); party-pack meals (Bryan, Harvey, & Misup, 1981); soups; pasta and other Italian foods; and Japanese box lunches (Bryan, Fukunaga, et al., 1991). These data, with data collected in the previous decade, made possible specific recommendations on hazard analyses and HACCP systems for food service operations (Bryan, 1990a, 1990b, 1990c) and for ethnic foods (Bryan, 1988b).

Two more Food Protection Conferences were held at which national food concerns and policies were addressed. At a third conference, the HACCP concept was emphasized in both the food microbiology and food-processing task forces. Afterward, the format was changed and these conferences were directed primarily at critiquing the retail food code. As a result, regulations and associated inspections took on a dominant role in food protection agencies. (The term "food safety" came into use in place of "food protection" by some, but not all, agencies.)

1990s–The Media and Consumer Groups Become Aware of Foodborne-Disease Problems

The Public Health Service, International and Environmental Health

The Centers for Disease Control (CDC) began publishing five-year summaries of foodborne-disease outbreaks. CDC initiated a sentinel surveillance activity (called FoodNet) in five states, which has been expanded to eight states. Data are obtained on laboratory-confirmed cases of several diseases that can be foodborne. These data are used to estimate the incidence of foodborne diseases, presumably with more accuracy than before. CDC also initiated a collaborative interagency program (called PulseNet) involving 35 laboratories that use DNA analysis to characterize foodborne pathogens and transmit the data electronically. The Codex Alimentarius (international food laws) included the HACCP concept along with codes of food hygiene (Codex Alimentarius Commission, 1996). The National Advisory Committee on Microbiological Criteria for Foods endorsed the HACCP approach for food safety and set down seven principles (National Advisory Committee on Microbiological Criteria for Foods, 1997). USDA released regulations that called for mandatory HACCP programs for meat and poultry plants. FDA mandated these programs for certain commodities. A national conference on food issues stimulated a President's Initiative for Food Safety. This development has provided momentum and funds for several programs dealing with foodborne-disease surveillance and food safety.

WHO continued to release expert-committee reports on topics associated with the 1984 food safety report. These reports included recommendations for health education (WHO, 1991) and use of the HACCP approach (WHO, 1993a, 1993b). It also published a manual on conducting hazard analyses in developing countries (Bryan, 1992). ICMSF wrote two more books, one on microbiological specifications of food pathogens (ICMSF, 1996) and the other an update on the microbial ecology of food commodities (ICMSF, 1998). A HACCP manual focused on prevention of foodborne diseases was published by IAMFES (Bryan, Bartleson, et al., 1991). Hazard analyses of home-prepared foods were continued in Pakistan (Bryan, Teufel, Roohi, et al., 1992a) and in Zambia (urban and rural districts) (Schmitt et al., 1997). Analyses were done also of street-vended foods (Bryan, 1993) in Pakistan (Bryan, Teufel, Riaz, et al., 1992a; Bryan, Teufel, Riaz, et al., 1992b; Bryan, Teufel, Roohi, et al., 1992b; Teufel et al., 1992) and Zambia (Bryan, Jermini, et al., 1997; Jermini et al., 1997). Despite the diversity of foods and cultures in the different countries, the hazards identified were similar (Bryan, 1988a, 1995, 2000). These were highly contaminated raw foods, high cooking temperatures, long-term room or outdoor holding of cooked foods during which considerable microbial growth occurred, inadequate hot-holding, insufficient reheating to kill pathogens, and some (less than anticipated) hand and environmental contamination. These hazards were confirmed by high microbial counts and pathogens found on raw foods, as well as on or in foods that were held for long durations at room or outdoor ambient temperatures and overnight.

Foodborne Diseases and Their Control

In the 1990s, *Cryptosporidium* and *Giardia* became the most common cause of waterborne outbreaks. A few foodborne outbreaks caused by these parasites also have been identified. *Cyclospora* was epidemiologically traced to raspberries grown in Guatemala (Herwaldt, Ackers, & Cyclospora Working Group, 1997). Water on farms had been frequently contaminated by *E. coli* or coliform bacteria, and the berries had been handled by many workers. This incident caused much concern about raw agricultural products from developing countries. A fifth edition of the IAMFES manual on foodborne-disease-outbreak investigation (Bryan et al., 1999) and the second edition of the IAMFES manual on waterborne-disease-outbreak investigation were published (Bryan et al., 1996). Suggestions for improvement of surveillance for foodborne diseases were made (Bryan, Guzewich, & Todd, 1997; Bryan, Todd, & Guzewich, 1997; Guzewich, Bryan, & Todd, 1997; Todd, Guzewich, & Bryan, 1997).

The major outbreak that caused reaction by the press and the federal government, however, was *E. coli* O157:H7 gastroenteritis traced to a popular hamburger chain in the Pacific Northwest (Davis et al., 1993). There were more than 500 laboratory-confirmed cases, mostly in children, of whom 47 developed hemolytic uremic syndrome and four died. The national media became obsessed with this incident. Consumer groups were concerned, and this concern added pressure to the federal agencies to revise their control programs. Cooking-temperature standards for hamburgers were established, and a revised and greatly improved food code for retail foods was published and periodically revised (FDA, 1995–1999).

2000s–Continuing Dilemmas of Emerging Diseases, and Their Solutions Through Balancing of Science, Education, and Politics

In the present decade, several of the activities initiated previously have continued and a few have intensified. The decade will be characterized by rapid communications and mass-media interpretation of events and policies.

Trying to predict the future is risky, but some events can be predicted through reflection on the past. With each passing decade, year, or lesser division of time, events occur that affect public health. Leaders change, policies change, reorganizations occur, previously unknown foodborne pathogens and toxicants are identified, and new food technologies are developed that may significantly affect food safety either by creating an environment in which pathogens spread, survive, and flourish or by eliminating or otherwise controlling pathogens. Foodborne-disease outbreaks will occur, and some will be considered crises at the time and get public attention. These incidents will influence change in the policies and practices in public-health and regulatory agencies and in the food industry.

It is hoped that decisions about these events will be science and epidemiology based, practical, and not greatly influenced by the panic of the moment or pressures from uninformed, but action-demanding groups. Rational decisions will have to be made, so be prepared!

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continued on page 22

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continued from page 21

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continued on page 24

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continued from page 23

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