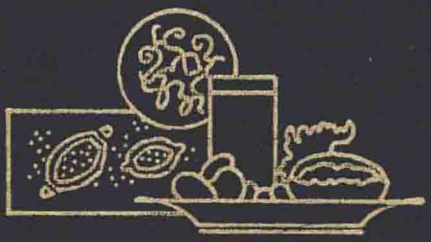

FOODBORNE & WATERBORNE DISEASES:

THEIR EPIDEMIOLOGIC CHARACTERISTICS

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THEIR EPIDEMIOLOGIC CHARACTERISTICS

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Preface

The aim of this book is to familiarize the reader with certain characteristics of foodborne and waterborne diseases, a knowledge of which is necessary for their prevention and control.

The various infective and toxic agents—bacterial, viral, protozoan, parasitic, fungal, and chemical—capable of causing gastrointestinal disease or poisoning when ingested in contaminated food or water are discussed. Their incubation periods, their modes of transmission, and their periods of infectibility are presented. Their clinical signs and symptoms and laboratory diagnosis are outlined for their identification. Measures for their prevention are recommended.

Guidelines for the investigation and control of cases and of outbreaks of foodborne and waterborne diseases are given and examples of such investigations made by the senior author (I.J.T.) are presented as illustrations. Illness resulting from the mishandling of foods in food-processing, food-serving establishments and in the home is discussed. A summary of the reports prepared by the United States Public Health Service of the annual incidence of outbreaks of foodborne and waterborne diseases in the United States is also included.

A chapter is devoted to the discussion of plants that are poisonous when ingested. Another chapter describes poisons that are naturally contained in certain foods and types of illness they may cause.

References from many sources have been included. The reader will note that with the creation of the new Department of Education and its removal from the Department of Health, Education and Welfare (HEW) in 1980, the latter agency is now known as the Department of Health and Human Services (HHS).

As the use of technical and medical terminology could not be avoided, a glossary of any such terms that appear in the text is included.

Not only will the book prove instructive to students of schools of public health, administrative medicine, food sciences, hotel management, and

those attending agricultural colleges, but also the material in the book should prove of assistance and guidance to health officers and personnel on their staff, such as epidemiologists, sanitary engineers, sanitarians, veterinarians, nurses, nutritionists, health educators, and social workers. Personnel in charge of quality control in food manufacturing plants may also benefit from the book.

It is hoped that it will provide valuable information to alert persons engaged in the various phases of the food industry whose responsibilities include providing the public with nourishment that is wholesome and free of pollution, contamination, and adulteration.

Officials concerned with maintaining the purity of drinking water will find essential facts for the prevention of contamination of the water supply in their charge.

Lastly, it is hoped that the reader will enjoy the occasional departure from pedantry, such as the philosophic discussion of sanitation, food, and water (Chapter 1), the occasional description of a historic epidemiologic occurrence such as "The Case of the Broad Street Pump" (Chapter 1), the relating of an interesting anecdote as "*Salmonella* vs Sanella" (Chapter 2), using a quotation from the past as Moses Maimonides on food poisoning (Chapter 5), as well as the descriptions of some of the experiences of the senior author in the performance of his duties as epidemiologist in a county with a population of approximately 1,750,000 people.

I. JACKSON TARTAKOW
JOHN H. VORPERIAN

October 1, 1980

Dedicated to our esteemed colleague, Dr. George G. Cook, who for many years served as Chairman of the Food Technology Department at SUNY, Farmingdale, N.Y.

Contents

1

Introduction

A microscopic layer of fecal organisms may be said to cover the whole of humanity, the thickness varying directly with the degree of personal hygiene of each individual and the type of sanitation existing in the environment of the locality he inhabits. This view may be confirmed by the ubiquity of *Escherichia coli* outside of its natural habitat, the colon. In spite of this condition, these organisms, except for some unusual pathogenic strains, do not produce disease. One person, however, may transmit an intestinal disease to another if he himself has or has had the disease and has become an acute, temporary, convalescent, or chronic carrier with his feces containing the causative microorganism.

Such a carrier, if he is engaged in the production, preparation, or service of foods consumed by persons outside his own household, constitutes a danger to the community. He must therefore be prevented from engaging in his occupation until he is fully recovered and it is established by laboratory examination that he has been relieved of his carrier state.

All food handlers must adhere to strict sanitary techniques so as not to endanger the public health. One of the simplest and most effective measures they must observe before handling any food is the washing of hands, particularly after the use of the toilet. Another is the prompt storage of all raw and prepared foods under proper refrigeration (below 7.2°C or 45°F) so as to arrest the multiplication of any pathogen that may have been introduced into the food.

In addition to the spread of foodborne diseases by man, a number of domestic and game animals may also be carriers of organisms capable of causing enteric diseases in humans. This is especially true of animals whose flesh is eaten by man. For example: turkeys and other fowl may transmit salmonellosis to man; pork, beef and fish, if harboring various types of tapeworms, may transmit them if improperly cooked; pork is also capable of causing trichinosis; tularemia may be acquired by the ingestion of inadequately cooked meat of infected wild rabbits; and raw

milk from infected cows will cause brucellosis. Fortunately, the high temperatures required for cooking such meats and the pasteurization of milk inactivate the pathogens and protect man from infection. Even contact with the urine or feces of the family dog or other pets (turtles) may result in illness by hand-to-mouth spread or contamination of food.

When such tainted food is eaten, the invading organisms on entering the gastrointestinal tract multiply in large numbers and cause various forms of gastroenteritis. The infective agents may be bacteria, viruses, helminths (worms), or protozoa. Among the diseases caused by bacteria are salmonellosis and typhoid fever, shigellosis, cholera, streptococcal sore throat, and food poisoning by *Clostridium botulinum* and *Staphylococcus aureus*. The latter two produce an enterotoxin in the contaminated food before it is ingested, and it is the toxin rather than the bacilli in the digestive system that produces the illness.

Viral contamination of food may result in viral hepatitis if the food is carelessly handled by a person suffering or convalescing from the disease and harboring the virus in his feces. Other foodborne viral diseases are lymphocytic choriomeningitis and epidemic hemorrhagic fever which infected United States troops in Korea.

Worms, among them intestinal roundworms, tapeworms, and flukes (nematodes), may be transmitted to man by infected persons or animals. The eggs or larvae are introduced into salads or other foods either by hands contaminated with human or animal feces, or by soil containing the eggs. In the intestinal tract, the eggs hatch and migrate to other organs by way of the lymphatic or circulatory system.

Protozoan foodborne infections may also be transmitted by fecal contamination of food or water; amebiasis (amebic dysentery) and giardiasis are two such diseases.

The question may arise as to how one can tell that an item of food is spoiled and unfit for consumption (the term ordinarily used is "human consumption," but that is avoided since any food unfit for human consumption is also unfit for animal consumption). Most meats, including fowl, fish, and shrimp, usually have a disagreeable odor when they are spoiled or contaminated. In addition, uncooked fish meat that pulls away easily from bones; dressed fowl that is sticky to the touch; and beef, pork, and similar fresh meats that have become slimy should be considered unusable as food.

A good test for canned foods is to note their tops and bottoms to determine whether they have swelled out into dome-like shapes. This indicates that the contents have spoiled, usually because of a slightly open seam permitting a gas-producing microorganism to enter and contaminate the contents. If an attempt is made to open the can, there will be a rush of escaping gas and an abnormal odor will ensue.

Salads such as those made from chicken, eggs, tuna, or ham must be kept refrigerated at a temperature below 7.2°C (45°F) until ready to eat. Similarly, custard-filled pastries and cold cuts require constant refrigeration to arrest the growth of any pathogenic organisms that they may contain.

Food is not the only vehicle of transmission of gastrointestinal diseases. Water polluted either directly with feces from patients or carriers or indirectly by fecal containing sewage is another form of spread. Epidemics of typhoid fever and cholera in the past have incriminated polluted water supplies.

Attention is called to a particular phase pertaining to water that may surprise many people. Few persons realize that the water they drink, cook with, and bathe in has been *recycled* as is done with old newspapers and discarded aluminum. The glass of crystal clear refreshing water one is drinking may contain many molecules of water that have passed one or more times through the digestive and urinary tracts of several other humans. The urine and other fluids that are excreted by living beings consist of water in which body waste products are dissolved. These undergo some form of sewage treatment and their diluent (water) is then returned as an effluent to the surface, joining a body of water such as a stream or lake that may serve as a water source. Should the effluent empty into the sea, the molecules of water under discussion may be returned to the atmosphere by evaporation and be condensed as rain or snow falling to the ground.

In rural areas, the liquid contents of cesspools percolate through the sandy soil that acts as nature's filter, oxidizing its organic matter and straining out the bacteria that it may contain. The filtrate thus reaches an underground impervious stratum or water table and may be tapped when a well is sunk, or it may appear on the surface as a spring.

Molecules of water thus reconditioned by nature may pass through a number of persons. They do not cause disease *per se* unless they are recontaminated with pathogenic organisms shed by sick persons or carriers or are polluted by a toxic chemical waste product.

An early classic illustration that disease may be conveyed by water was made in Great Britain in 1854 by John Snow, epidemiologist, and John York, Secretary and Surveyor of the Cholera Inquiry Committee (Snow and York 1855). The study is known as "The Case of the Broad Street Pump." Cholera at that time was prevalent in London but occurred with epidemic intensity and great fatality in the district about Broad Street. Epidemiologic study of the epidemic revealed that most of the victims had used water from the well located on that street. On examination of the well, it was found that the mortar joints between the bricks making up its sides had been washed away and served as a sieve through which

drainage from an adjoining similarly defective cesspool had been percolating for a considerable period of time. The cesspool served a house in which there were 4 severe cases of cholera. The epidemic was promptly arrested by a simple procedure, namely, the removal of the handle of the Broad Street pump.

A markedly significant reduction in the incidence of foodborne and waterborne diseases has been brought about by improved living conditions, modern sanitation, chlorination of water supplies, pasteurization of milk, prophylactic immunization of contacts and susceptibles, introduction of mechanical refrigeration, sanitary design of food equipment, and prompt treatment of infected persons. Typhoid fever may be cited as an example. Sir William Osler, the renowned physician, has stated that "typhoid fever has been one of the great scourges of armies and has killed and maimed more than powder and shot." He pointed out that in the Spanish American War in the national encampments among 107,773 men, there were 20,738 cases of typhoid fever with 1580 deaths. Camp pollution, contamination of the water supply, and fly transmission to food were blamed for the outbreaks. On the other hand, in World War I, with the application of modern sanitation and the vaccination of all enlisted men, typhoid fever did not prevail to any extent.

Public health laws pertaining to food manufacturing, processing and handling, periodic inspection of establishments where food is prepared and served, and the education through various media of commercial food handlers, as well as housewives, in the proper preparation and storage of foods have done much in the control and prevention of foodborne diseases.

Modern indoor plumbing with the sanitary disposal of feces, proper sewage treatment, and the protection, purification, and chlorination of public water supplies may be said to be responsible for the rare occurrence of waterborne outbreaks.

In general, it may be said that with few exceptions man serves as the main reservoir of infection of the more serious gastrointestinal diseases. When he is infected, his feces contain the organisms that are responsible for his illness and capable of causing the disease in others. It is therefore of the utmost importance for those of us who are charged with the preservation of the public health to exercise every effort to prevent one man's feces, no matter how infinitesimal the quantity may be, from entering another man's gastrointestinal tract through the foods he eats and the liquids he drinks.

In discussing the numerous diseases transmitted by food and water, a certain degree of repetition is unavoidable. A high percentage of the diseases have similar signs and symptoms with the majority of them having, among other complaints, the gastrointestinal triad: vomiting,

abdominal cramps, and diarrhea. There may also be similarity in their mode of transmission, in their method of control, and in the steps necessary for their prevention. Rather than referring the reader to previous chapters in the book, pertinent information for each disease is described even if it has already been mentioned in relation to another disease.

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2

Salmonellosis

Before we turn our attention to the microorganism known as *Salmonella*, it is interesting to note that a discussion regarding the bacillus, usually reserved for persons of a scientific background, recently took place among the members of the United States Senate. It was not the pathogenicity of the organism or the potential danger that it presented to their constituents that concerned the legislators. It was merely a question of semantics and its alleged influence on one particular industry.

According to an editorial that appeared in *Nutrition Today* in 1967 (Enloe 1967), Senator Warren G. Magnuson of the state of Washington introduced in June of that year a bill (S-2019) that would alter, for the first time in the history of the United States Congress, the name of a microorganism and of the disease that it causes. The senator's contribution to medical nomenclature stated:

> Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, that (a) it is the policy of the Federal Government that the term "sanella" should be employed to designate the particular genus of bacteria presently designated by the term "salmonella" and that the term "sanellosis" shall be employed to designate the particular disease presently designated by the term "salmonellosis."

The bill then went on to command that all "departments, agencies and instrumentalities of the Federal Government . . . shall comply with the policy . . . ."

It is suspected that this exceptional piece of legislature was proposed in response to pressure brought by the salmon industry lobby that feels that the American public erroneously associates the bacterium *Salmonella* with their favorite product, and that there is a causative relationship between the fish and the disease salmonellosis.

It is purely coincidental that the name of the scientist who first described the *Salmonella* bacillus, and after whom it was named, should

be synonymous with that of the anadromous fish that breeds in the rivers in the senator's state. The only time an actual association would be established between the bacillus and the fish would be if the two were to come together because of faulty processing or handling. The public might then see a front-page news headline such as "Salmon Causes Salmonellosis."

To our knowledge the senator's bill has not become a law and it is still legal to refer to the organism and the disease by their traditional names. These shall be used throughout the discussion that follows.

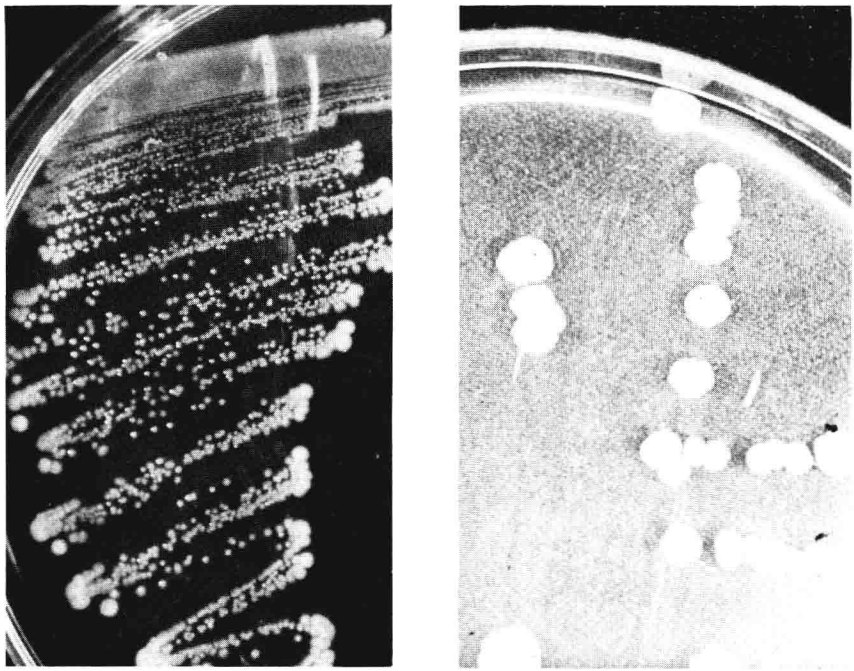
Characteristics

Salmonellosis, formerly referred to as paratyphoid infection, is an acute form of enteritis caused by a Gram-negative rod-shaped bacillus known as *Salmonella*, named after Dr. D.E. Salmon, who first described it in 1885. There are more than 1000 different strains or serotypes of the organism with additional ones being constantly uncovered. The various strains are differentiated by agglutination tests. Some strains have greater pathogenicity than others with many capable of attacking animals as well as man. The types most commonly found in the United States are *S. typhimurium*, *S. enteritidis*, *S. heidelberg*, *S. paratyphi A* and *B*, *S. infantum*, *S. choleraesuis*, *S. newport*, *S. st. paul*, *S. derby*, and *S. oranienburg*. The most pathogenic member is *S. typhi*, which causes typhoid fever and is discussed at length in Chapter 3.

Although cases occur throughout the year, the greatest number is usually reported between the months of July and September (see Fig. 2.2).

Salmonellosis is usually a form of gastroenteritis characterized by a sudden onset with fever, griping and severe abdominal pain, nausea and vomiting, anorexia (lack of appetite), foul smelling diarrhea, weakness, and dehydration. Although *Salmonella* usually invades and localizes itself in the gastrointestinal system, in extreme instances it may invade other systems (such as respiratory, central nervous, genitourinary, or cardiovascular) causing pneumonia, meningitis, pyelonephritis, endocarditis, and pericarditis. Severity depends on the serotype of the invading organism, the dosage of bacteria ingested, and certain host factors such as age, debilitation, and concurrent illness. The fatality rate is about 4%, the very young and very old being most vulnerable.

The incubation period of salmonellosis or the time required for symptoms to appear after ingestion is 6 to 48 hr, but illness usually occurs in 12 to 24 hr and may last from 3 days to 3 weeks during which time the patient may be a temporary or convalescent carrier excreting *Salmonella*



Courtesy of Elliot Scientific Corp. and Abbott Laboratories

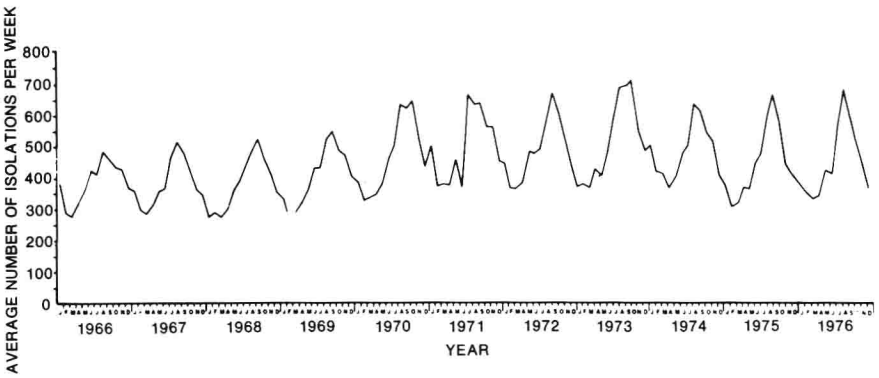
FIG. 2.1. *SALMONELLA* SPECIES
LEFT—Culture on Endo agar: colorless, non-lactose fermenting colonies.
RIGHT—Pure culture on Endo agar.

in his feces and capable of contaminating food consumed by other persons.

Sources of Infection

Although man serves as the main reservoir of infection, animals, especially those whose flesh serves as food, such as turkeys and chickens, or those present in the home as dogs and pet turtles, also play a role in the spread of salmonellosis.

As previously stated, salmonellosis is transmitted by the ingestion of the causative organisms in food contaminated by infected feces from man or animal. Among foods most frequently involved because of their ability to support the growth and multiplication of *Salmonella* are whole eggs and egg products (frozen or dried eggs, egg albumin, and egg yolk, especially from duck eggs), poultry, meat and meat products, commer-



From Cent. Dis. Control (1977)

FIG. 2.2. THE REPORTED NUMBER OF ISOLATIONS OF SALMONELLAE FROM HUMANS, BY MONTH, UNITED STATES, 1966–1976

cially processed meats and poultry, pies, sausages, products containing eggs, unpasteurized whole milk, and powdered milk and milk products.

The responsibility for the transmission of salmonellosis to man by domestic animals rests on the shoulders of man, as he infects the animals he raises or breeds with the feed he offers them. Animal feed and mixes often are made from waste animal by-products such as fish meal, poultry meal, meat scraps, and tankage—mostly the refuse of animals. These products are primary sources of *Salmonella*. As they are intended for animal use, they are processed with little regard for cleanliness and sanitation. The feed, frequently contaminated, infects the animal that eats it. The animal is eventually slaughtered for human consumption and its intestinal contents or diseased tissues contaminate his flesh, thus infecting man if the meat is inadequately stored or improperly cooked.

Even the innocuous pet turtle may become a carrier and cause human salmonellosis, particularly in young children. The turtle becomes infected, like other animals, by being given contaminated feed. Children invariably handle the pets and contaminate their hands with fecal containing tank water. They then fail to wash their hands before eating, thus infecting themselves. Cultures of patients' feces and of tank water have revealed the presence of the same serotype of salmonella on numerous occasions.

Sometimes illness has been blamed on canned foods. Such views are unfounded as the organisms are not found in unopened cans since the processing timing and temperatures of canning preclude the survival of any microorganism. Contamination of such foods takes place after the can has been opened and its contents handled in an unsanitary manner

by a carrier with soiled hands or by utensils. However, one must avoid dented and swollen cans as their contents invariably are contaminated perhaps through an opening in the seam following a fall.

Prevention

The prevention of salmonellosis may be accomplished by observing the following recommendations:

(1) All foodstuffs from animal sources should be thoroughly cooked.
(2) Avoid recontamination of foods after cooking by careful handling.
(3) Avoid eating raw, dirty, or cracked eggs.
(4) Pasteurize milk and milk products.
(5) Refrigerate prepared foods as well as leftovers during storage before use.
(6) Educate food handlers and homemakers in the importance of adequate refrigeration of foods, handwashing before food preparation, maintaining a sanitary kitchen, and protecting foods from rodent and insect contamination.
(7) Periodic meat and poultry inspection by trained personnel with supervision of abattoirs, as well as federal inspection of animals (cattle, sheep, goats, swine, and horses) in interstate shipment with the purpose of excluding diseased animals and to control the sanitary handling of meats.
(8) Animal feed should be cooked or heat treated against contamination with *Salmonella*.
(9) Protect foods from contamination with rat or mouse feces and from contact with houseflies.

Diagnosis and Treatment

Laboratory diagnosis of salmonellosis is most satisfactory when *Salmonella* are isolated from both the suspected food (if available) and the patient's feces. It appears in the feces during the acute symptoms and often disappears when the symptoms subside. Agglutination tests are not significant as the titer is not sufficiently increased to be diagnostic.

The following steps may be followed for the care of patients:

(1) All cases and outbreaks must be reported to local health authorities.
(2) Infected person's feces and soiled articles should be disinfected; if home has modern flush toilet connected to an adequate sewage treatment system, patient's feces may be discharged untreated directly into toilet.