Foodborne Disease in California

with special reference to

Clostridium perfringens (welchii)

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ABOUT 2,300 foodborne and waterborne outbreaks, affecting almost 100,000 persons, were reported in the United States for the 10-year period ended in 1960, according to Dauer (*1*). He stated that many foodborne disease outbreaks, particularly family outbreaks, probably never come to the attention of local health authorities. Many authorities have suggested that the actual number of foodborne and waterborne outbreaks is at least 10 to 50 times greater than the reported number.

During 1951–60 California was one of three States with the highest reported rates of foodborne and waterborne disease outbreaks. An increasing incidence of foodborne disease has been attributed to *Clostridium perfringens* (*welchii*) in California.

The reported number of foodborne and waterborne outbreaks in the United States for 1951–55 averaged 1.4 per million population annually (*1*). For the same period, California reported 273 outbreaks, an annual average rate of 4.6. For 1956–60 California reported 553 outbreaks, an annual average rate of 7.2 per million population. Similarly computed rates for other States indicate that in 1951–55 California tied for first place with Oregon, and for 1956–60 California had the second highest rate in the nation, with Maine leading with a rate of 7.6.

Although we believe that California's rates reflect relatively good reporting rather than inadequate preventive measures as compared with other States, we feel there is considerable margin for improvement in preventive measures.

For the years 1957–61, about 50 percent of California's reported foodborne outbreaks were classified as "etiology unknown" (see table). This percentage is comparable with that for the United States as a whole. During 1961, only 24 of California's 79 health jurisdictions (58 full-time and 21 part-time health officers) reported foodborne outbreaks.

In many areas there appears to be positive correlation between the amount of activity and direction of interest of those responsible for communicable disease control and the amount of foodborne disease reported. From what we call "other intelligence," for example, personal contacts, newspapers, and radio reports, we know that some outbreaks are investigated locally but are not reported officially to State health authorities. Also, outbreaks occur which are not investigated. At the local level, it is often very difficult to distinguish small outbreaks from concurrent disease in the community. Late notification to local authorities seems largely responsible for the category "etiology unknown" remaining at about 50 per-

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cent of reported outbreaks. When late notification occurs, the incriminated foods are usually unavailable for laboratory examination.

Clostridium perfringens

Although *C. perfringens* was first described as a cause of food poisoning by McClung in 1945 (*2*), no marked increase occurred in the United States in the recognition of outbreaks caused by this organism. Failure to use anaerobic culture techniques to verify the etiologic agent may have effectively hidden outbreaks epidemiologically suggestive of *C. perfringens*.

Since 1945, notably because of the work of Hobbs, *C. perfringens* has assumed greater importance, particularly in the "general outbreak" category in England and Wales. In these countries, during 1949–58, although *C. perfringens* was responsible for only 1 percent of foodborne incidents (incident being defined as any situation in which illness occurs in the form of a sporadic case, family or general outbreak, or both), it was responsible for 9 percent of the general outbreaks (*3*). During this period in the United States, *C. perfringens* had been suspect on some occasions, but rarely reported as the etiologic agent responsible for outbreaks. Hart and associates described a 1959 outbreak which affected nearly half the 450 passengers who had been served a turkey dinner aboard a special railway train (*4*). Large members of *C. perfringens* and enterococci were isolated from the turkey; however, the causative factor of the outbreak was not conclusively identified.

The increasing incidence of reported *C. perfringens* in California is shown in the table. The first reported outbreak, affecting 26 persons, occurred in 1959 (*5*). In 1960 two outbreaks, affecting 108 persons, and in 1961 five outbreaks, affecting 464 persons, were reported. During 1961 *C. perfringens* outbreaks accounted for 5.5 percent of the total reported outbreaks in California and 17.5 percent of the total persons affected. This fourfold increase over 1960 made this organism responsible for the largest number of cases due to a single known etiologic agent during 1961 in California.

Early in 1962, we assisted in the investigation of a foodborne outbreak of illness at a large State institution for the mentally ill in California. Smear samples of the creamed turkey served at the evening meal showed large numbers of a gram-positive organism similar to *C. perfringens*. Subsequently, *C. perfringens* was isolated from the food and from stool specimens submitted by several patients and employees residing in different areas of the institution. Similar serotypes were isolated from the food and from the stool specimens, and they coincided with Hobbs' provisional serotypes. Stool

Outbreaks and cases of food poisoning, by etiology and year, California, 1957–61

Etiology	Total				1961		1960		1959		1958		1957	
	Outbreaks		Cases											
	Number	Percent	Number	Percent	Number outbreaks	Number cases	Number outbreaks	Number cases	Number outbreaks	Number cases	Number outbreaks	Number cases	Number outbreaks	Number cases
Total	545	100.0	11,866	100.0	90	2,650	94	1,854	124	1,693	136	3,797	101	1,872
Etiology unknown	270	49.5	5,706	48.1	50	1,258	47	689	75	949	65	2,180	33	630
Staphylococcus	172	31.6	2,618	22.1	16	304	28	682	30	326	54	827	44	479
Salmonella	42	7.7	1,553	13.1	5	194	10	296	9	363	5	110	13	590
Clostridium perfringens	8	1.5	598	5.0	5	464	2	108	1	26	----	----	----	----
Chemical	38	7.0	465	3.9	8	359	5	15	7	22	10	36	8	33
Other	15	2.8	926	7.8	6	71	2	64	2	7	2	644	3	140

NOTE: Percentages are rounded independently and may not add to 100.0.

SOURCE: California Department of Public Health: Morbidity reports.

specimens from the same persons did not yield the same serotypes 2 weeks later.

We believe that this is the largest single outbreak due to *C. perfringens* reported to date. However, two factors made it particularly difficult to assess the true incidence at this institution: (*a*) the peak incidence occurred between 2 a.m. and 4 a.m., the hours when minimal staff is in attendance, and (*b*) the nature of the population made collection and tabulation of history data questionable. Despite these difficulties, the hospital staff estimated that approximately 800 to 900 of the 2,227 patients were affected.

When a survey was conducted several days after the outbreak, it was difficult to substantiate the estimated number of persons affected. Intensive efforts were then made to tabulate the attack rates for those patients and staff considered by the hospital authorities most likely to provide reliable data. The groups selected included 38 persons on the staff who ate the suspected meal, and 312 patients from different areas of the institution. Thirty-six of the staff, an attack rate of 95 percent, and 113 of the patients, 36 percent, were affected.

Applying the overall attack rate for the selected groups to the total patient population gave a total number ill similar to the original 800 to 900 estimated by the staff. The hospital employees ate the same food at the same time as the patients. Since the employee group can reasonably be considered more reliable and had reported a significantly higher attack rate than the patient group, the number of patients affected may have been much higher.

In our general experience with clostridial outbreaks, epidemiologically incriminated foods have been meat or its associated broth or sauce, or both. The liquids used as a base for broth or sauce are usually prepared from the meat, and they have a high protein content. A review of food preparation history indicates a product usually sufficiently cooked to break down protein and to drive off oxygen. This process, in addition to the natural oxidation-reduction potential of meat, is sufficient to support anaerobic growth.

The strains of *C. perfringens* usually responsible for foodborne illness in England and Wales produce spores which are extremely heat resistant and survive boiling for 1–4 hours (*6*). However, McKillop (*7*) observed *C. perfringens* outbreaks associated with non-heat-resistant types. Therefore, large masses of spore-containing cooked food, inadequately or slowly cooled, or foods left simmering under low heat, provide an excellent opportunity for spores to germinate into the vegetative form and to multiply rapidly. The temperature range for multiplication of vegetative forms is rather wide. Under favorable conditions the number may increase nearly 200-fold in a 3-hour incubation period in a temperature range of 102°–120°F. (*8*). It becomes obvious therefore that astronomical numbers of organisms may be present in some of the incriminated foods. Foods, though initially free from clostridia, may be contaminated after cooking, through handling or from utensils, dust, and cutting blocks. The organism is ubiquitous in nature and can be routinely cultured from dust, soil, kitchen floors, and chopping blocks (*6*). Smith (*9*) reported that the intestinal tracts of all animals, including man, would yield *C. perfringens* if adequate selective culture techniques were employed. Hobbs and Wilson (*10*) found as high as 8.9 percent of carcass beef contaminated with this organism, and Yamamoto and associates (*11*) have shown that 28 percent of 110 turkey fecal samples contained heat-sensitive *C. perfringens*.

Preventive Measures

Hobbs (*6*) has stated, "Whereas the elimination of organisms of the Salmonella group from foods should be regarded as both essential and practicable it is suggested that to aim at freedom from Staphylococci would be difficult and from *Clostridium welchii* impossible." Clearly, control efforts must be directed toward prevention of the vegetative growth phase of the organism. Pressure cooking for an adequate time and at a high enough temperature will destroy the spores and thereby eliminate the possible availability of the vegetative phase for multiplication, provided the product is not recontaminated. Oven roasting is inadequate to destroy the spores short of spoiling the meat for eating.

Preparation of food the day before it is

served should be discouraged. When this is impracticable, the food should be cooked at a temperature above 140° F., cooled quickly to below 40° F., and kept cold in order to prevent the multiplication of organisms. So that meat will reach a roasting temperature quickly and will cool rapidly and adequately, it should be oven roasted in pieces no larger than 6 pounds. Foods, such as turkey à la king, which are usually prepared well in advance of a meal, should be reheated so that all the ingredients are brought to a boil. Particular attention should be paid to meat liquors to be used for gravy or broth. These liquids should be refrigerated in small containers and stirred frequently to promote rapid cooling.

The recognized ubiquity of *C. perfringens* seems to make the human carrier of little importance epidemiologically. Therefore, undue efforts to incriminate him or to exclude him from work are unwarranted.

Discussion

Foodborne disease caused by *C. perfringens* is ordinarily a mild clinical illness of man, with attendant low mortality. It is usually of short duration and is characterized symptomatically by abdominal griping and diarrhea, some nausea, and, infrequently, vomiting. Some affected persons may show a slight temperature elevation.

In the investigation of an outbreak presumed to be caused by *C. perfringens*, consideration should also be given to *Salmonella*, enterococci, and *Bacillus cereus* in differential diagnosis. The range of incubation periods for *C. perfringens* is 8–22 hours, with a mean of 10–12 hours. The clostridia involved in foodborne outbreaks are classified as belonging to type A; and in England and Wales most isolates have been highly heat resistant in the spore form. Hobbs has tentatively classed the members of the group which causes foodborne disease into 13 serotypes. In California not all outbreaks have yielded heat-resistant strains. Two outbreaks have yielded heat-labile strains that are serologically related to each other. Hobbs and associates (*12*) suggest that the property of heat resistance may be lost by a single passage on artificial media. It is apparently not yet clear whether heat-labile strains may be a primary cause of illness. However, in England most strains studied have been heat resistant.

According to Hobbs (*6*), the exact cause of the enteritis produced by *C. perfringens* is not known. However, large numbers of the active vegetative form of the organism are required to cause illness. The symptomatology suggests a toxic illness and yet the incubation period suggests infection.

Since illness due to *C. perfringens* is ordinarily rather mild, has a relatively long and variable incubation period, and occurs without the explosive onset characteristically associated with staphylococcal foodborne illness, the disease may not be recognized as being foodborne. This might be especially true in a population which is more conditioned to frequent bouts of gastrointestinal disturbance or in a population incurring endemic illness due to other causes including viral agents.

According to L. deS. Smith (personal communication and unpublished paper, 1960) and from our experience, undue harshness in blending or freezing of bacteriological specimens may make the recovery of organisms extremely difficult. Therefore, until this problem has been clarified, the epidemiologist investigating an outbreak presumably due to *C. perfringens* should keep specimens at refrigerator temperature, rather than freeze them, until they are examined at the laboratory.

Summary

During 1951–60 California was one of three States with the highest reported rates of foodborne outbreaks in the nation. However, about 50 percent of reported foodborne outbreaks in California are categorized as "etiology unknown," a percentage comparable with that for the total United States.

Reported cases of foodborne illness caused by *Clostridium perfringens* showed a fourfold increase in California between 1959 and 1961. An outbreak which affected an estimated 800 to 900 persons in a California mental institution in 1962 was attributed to *C. perfringens*. This is believed to be the largest single outbreak due to *C. perfringens* reported in the United States to date.

The recognized ubiquity of clostridia makes imperative vigilant scrutiny of food-preparation practices, particularly the preparation of food far in advance of consumption. Some strains of *C. perfringens* produce heat-resistant spores which withstand ordinary cooking. Therefore, large masses of spore-containing cooked food, inadequately or slowly cooled, or foods left simmering over low heat, provide an excellent opportunity for spores to germinate into the vegetative form and multiply rapidly. Since large numbers of the organism are necessary to produce illness, efforts at prevention must be directed toward preventing growth of the vegetative phase.

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