Control of Staphylococcal Food Poisoning

BENJAMIN E. HODGE, M.D.

STAPHYLOCOCCAL food poisoning is overwhelmingly the most prevalent of food-borne infections in the United States. The need for improved methods of controlling the disease is indicated by the number of outbreaks reported in the annual summaries of disease outbreaks, which show little evidence of decrease in incidence (*1–4*).

Factors responsible for outbreaks of staphylococcal food poisoning have not been clearly defined. It is difficult, if not impossible, to determine those conditions required to render food poisonous because no satisfactory laboratory test has been found for the presence of staphylococcus enterotoxin in food (*5–7*). At present, the only means of clarifying these factors appears to be through analysis of unselected outbreaks of this disease.

Ninety-five outbreaks of staphylococcal food poisoning in 1955 and 1956, reported in the weekly communicable disease summaries issued by the Public Health Service, were surveyed. More complete data on 89 of them were obtained from the State, county, and city health officers reporting the incidents.

Analysis of Outbreaks

The diagnosis of staphylococcal food poisoning is generally based on circumstantial evidence, not on demonstrated presence of enterotoxin in food. In this series the diagnosis was based on opinions of health officers originally reporting the outbreaks and on the finding of staphylococci in food. Since staphylococci are ubiquitous and many strains are not enterotoxigenic, the mere presence of staphylococci in food is not sound evidence for the diagnosis of this disease. However, in this survey, the diagnosis of staphylococcal food poisoning was supported by two types of supplementary evidence: the type of staphylococcus found in the incriminated food and the incubation periods of the outbreaks.

In the 75 outbreaks which reported such information, the organisms considered to be staphylococci were classified as follows:

Classification	*Number of outbreaks*
Coagulase positive	53
Coagulase negative	5
Staphylococcus aureus	45
Staphylococcus albus	1
Hemolytic	28

Thus, of 75 outbreaks, 71 percent of the staphylococci were coagulase positive; 60 percent, *aureus;* and 37 percent were hemolytic. Phage typing and bacterial counts were each reported in three instances, and kitten test for presence of enterotoxin once—too seldom to be of significance. These data indicate, but do not prove, that the organisms generally found were enterotoxigenic.

The incubation periods were recorded in 77 outbreaks.

Incubation period	*Number of outbreaks*	*Percent of outbreaks*
1–4 hours	61	79.2
5–8 hours	11	14.3
More than 8 hours	5	6.5

The incubation periods in this series agree with those accepted for this disease. In Feig's series (*8*), the incubation periods in 50.5 percent of the outbreaks of staphylococcal food

Dr. Hodge, who died November 28, 1958, was medical supervisor of the general services department of E. I. du Pont de Nemours & Co., Wilmington, Del., and for several years served on the medical staff of the Johns Hopkins Hospital, Baltimore.

poisoning were less than 4 hours and in 86 percent were less than 8 hours. Comparison of incubation periods of staphylococcal food poisoning with those of other common foodborne diseases shows the importance of this particular item. Feig reported the median incubation period of salmonellosis as 19.9 hours and of dysentery as 53.4 hours, and Dack (*9*) reported the incubation period of botulism as 12 hours to many days. Consequently, it appears that the outbreaks surveyed were classified as staphylococcal food poisoning with reasonable accuracy.

Factors Responsible

Dack showed that staphylococcal food poisoning may result after ingestion of certain foods which had been contaminated by enterotoxigenic staphylococci and had remained at proper temperatures long enough to produce dangerous amounts of enterotoxin. Overt infections of food handlers and uncleanliness have been commonly assumed to be the sources of contamination of food, although no general survey has been reported to determine the overall significance of such infections or unclean practices. Furthermore, types of food capable of acting as vehicles of this disease and methods of handling food permitting formation of dangerous amounts of enterotoxin have not been clearly defined.

Types of Food Acting as Vehicles

In 94 out of 95 outbreaks, the vehicle of this disease was reported as cooked food, which contained large proportions of protein. This is in agreement with other observations. In 63 outbreaks, or 67 percent, the vehicles were food mixtures such as tuna salad, turkey salad, creamed chicken, potato salad, meat loaf, chicken pie, egg salad, and cream-filled pastries. Such mixtures are usually handled extensively after cooking.

Raw and freshly cooked meats were not reported in this series and cannot be found recorded in the literature as the vehicle of staphylococcal food poisoning, regardless of state of preservation of meat prior to cooking. The fact that many people throughout the world consume putrid meat with impunity indicates that raw foods probably are incapable of acting as vehicles of this disease. Unfortunately, no experiments have been reported to substantiate or deny this thesis.

Vegetables, unmixed with high-protein foods, were not reported as the vehicle in any outbreak in this series. Careful differentiation should be made between vegetables mixed with high-protein foods, such as potato salad containing eggs or mashed potatoes prepared with milk and eggs, and vegetables unmixed with any high-protein items.

Food Handlers' Infections and Uncleanliness

Specific questionnaires were sent to all health officers originally reporting outbreaks to determine whether (*a*) food handlers were examined in connection with the outbreaks, (*b*) any infection of food handlers was found, (*c*) the utensils and premises were inspected, and (*d*) any unclean practices were discovered.

Visible infections of food handlers were reported in only nine outbreaks and were listed as "some lesions on hands of one food handler," "burn from bleach," "infection of eyelid," "blister on hand," "cuts on hand," "two bakers had chronic paronychiae," "skin lesions," "healing lesion on hand," and "one cook had eczema." Thus, infections of food handlers, including questionable ones, were not commonly reported in association with outbreaks of staphylococcal food poisoning.

Insanitary practices were reported in only 13 outbreaks. In four outbreaks the practices were described as "unclean" without details given. Other descriptions were "roaches, flies, and unclean premises and equipment," "dirty refrigerator," "debris on slicing machine," "not adequately sanitized," "sanitation poor in pastry shop," "utensils dirty, garbage storage poor," "custard gun eroded," "careless," and "terrible."

Abnormal environmental conditions, including both infections of food handlers and uncleanliness, were reported in a total of 21 outbreaks—1 outbreak reporting both uncleanliness and infection of food handler. In 50 outbreaks, examinations of food handlers and inspections of premises revealed neither infections of food handlers nor uncleanliness. In 24 additional outbreaks, there was no record of either infection or uncleanliness, but reports on this group should be discounted since the data were not complete. Thus, of 71 outbreaks reporting complete information, in 70 percent no obvious environmental conditions which could act as a source of contamination of food by staphylococci were observed.

Methods of Handling Food

The manner of handling vehicles of these outbreaks was investigated through the following questions sent to various health officers. Was the vehicle of food poisoning inadequately refrigerated after cooking, and, if so, under what conditions and how long? Was the vehicle inadequately heated after cooking? If so, under what conditions and how long? Was the food left over or cooked the day before it was consumed?

Leftover food was reported as the vehicle of 81 outbreaks. In only five outbreaks was the vehicle food cooked on the day of consumption. No information was available in nine outbreaks. Thus, leftover food was the reported vehicle of this disease in 94 percent of 86 outbreaks reporting this information.

Unrefrigerated food was reported as the vehicle in 74 of 83 outbreaks supplying information on manner of handling food after cooking. The minimal length of time and temperature of keeping food unrefrigerated are of great importance in defining the rate of enterotoxin production resulting in food poisoning. The length of time food was kept unrefrigerated was tabulated.

Time period	*Number of outbreaks*
Less than 4 hours	6
4–8 hours	8
More than 8 hours	35
Unknown	25

From these data it appears that food can be rendered poisonous within 4 hours. However, careful scrutiny of the six outbreaks in which food was reported unrefrigerated for less than 4 hours shows that two of them involved cream-filled pastries. Here adequate chilling of the custard filling was evidently delayed long after being placed in the refrigerator because of insulation of the pastry capsule. In two other outbreaks food was alternately warmed and inadequately chilled. The two remaining instances both involved potato salad, which may have been unchilled for less than 4 hours. The author witnessed one outbreak in which potato salad containing eggs was prepared after 8 a.m. and consumed at 11:30 a.m.; six cases of staphylococcal food poisoning resulted. These cases indicate that unrefrigerated, cooked protein food may become poisonous within 4 hours, but that a period of 8 hours or longer is more common.

No precise information regarding the temperatures which permitted food to become poisonous could be obtained by examination of the circumstances of keeping the vehicles. Temperatures were recorded predominantly as "room temperature."

In 13 outbreaks, cooked protein food was reported inadequately heated. The circumstances appear to have been nearly ideal for bacterial growth: in five instances food was kept on a warm steamtable; and in one instance each in defective oven, in warming oven, under burnt-out infrared lamps, on warming table, and in oven with pilot light burning. The specific circumstances were not mentioned in three instances.

In four outbreaks the food was constantly refrigerated after cooking. Two of these outbreaks involved Boston cream pie and chocolate eclairs, in which encasing pastry acts as efficient insulation. We have found that 3 hours or more are required to lower the temperature of custard within eclairs from 80° to 50° F. when refrigerated constantly at 38° to 42° F. Thus, custard-filled pastries reported constantly refrigerated are, in fact, not chilled for a period of some hours. In the third outbreak the vehicle had been refrigerated in a thick mass in large containers, while the fourth outbreak involved tuna salad prepared with leftover deviled eggs. It seems likely that the vehicle in each of these four outbreaks was not promptly, constantly, and adequately chilled.

Table 1 summarizes the results of this survey. The vehicle in 99 percent of the outbreaks was cooked food which contained large proportions of protein, strong evidence that other types of food such as raw food, vegetables, and other low-protein foods are incapable of acting as vehicles of this disease. Since 70 percent of 71 outbreaks were free from obvious infections of food handlers and without unclean practices, it appears sound to conclude that such abnormal environmental conditions are not the prevailing factors determining the development of this disease. On the other hand, in 83 outbreaks reported on fully, the vehicle was high-protein food, unrefrigerated after cooking in 74 instances, kept warm after cooking in 13 instances, and in 8 instances the food was alternately warmed and left unrefrigerated. Therefore, in 79 out of 83 outbreaks the vehicle was unrefrigerated or warmed after cooking, or both. These numbers clearly show that the determining factor in the development of staphylococcal food poisoning lies in permitting cooked protein food to remain warm or at room temperature for periods of 4 hours or longer.

Discussion

Outbreaks of staphylococcal food poisoning have been generally considered to be dependent on two major factors: (*a*) some abnormal source of contamination of food by enterotoxigenic staphylococci, such as infections of food handlers; and (*b*) keeping food under conditions that permit dangerous amounts of enterotoxin to form. In view of the relative infrequency of abnormal environmental conditions, it seems clear that food may be commonly contaminated by enterotoxigenic staphylococci under apparently normal, sanitary conditions.

Table 1. Summary of responsible factors in 95 outbreaks of staphylococcal food poisoning in the United States, 1955–56

Factors	Outbreaks		Number of outbreaks reporting this type of data
	Number	Percent	
Types of food:			
Cooked high-protein	94	99	95
Leftover	81	94	86
Food mixtures	63	67	95
Fresh cooked meat	0	--------	95
Raw meat	0	--------	95
Vegetables only	0	--------	95
Environment:			
Satisfactory	50	70	71
Uncleanliness	13	18	71
Infections of handlers	9	13	71
Method of handling food after cooking:			
Unrefrigerated or warmed, or both	79	95	83
Unrefrigerated	74	89	83
Warmed	13	16	83

Actually, a large percentage of normal persons have been shown to be carriers of pathogenic staphylococci. Getting and associates (*10*) reported that 18 percent of 122 food handlers who were apparently free of any infections but who were associated with 10 outbreaks of staphylococcal food poisoning were carriers of strains of staphylococci apparently identical with those strains found in the incriminated food. Allison (*5*) reported 33 percent of healthy persons as carriers of coagulase positive strains of staphylococci in the gastrointestinal tract. Blair (*11*) states, "Potentially pathogenic forms [of staphylococci] are constantly carried on the skin or in the nose by approximately 20 and 50 percent, respectively, of all individuals." In view of the large percentage of healthy persons who carry pathogenic staphylococci, it seems logical to assume that virtually all food may become contaminated by these organisms, regardless of the state of cleanliness and the presence or absence of infections in food handlers.

In this series of outbreaks there is sound evidence that staphylococcal food poisoning occurs only when cooked protein food remains for some time at approximately room temperature. None of the outbreaks involved consumption of freshly cooked food. These facts are not new, except in one respect. They indicate that this disease develops when protein food is neglected after cooking rather than because of a multitude of factors. They show that immaculate cleanliness and freedom from infection will not prevent outbreaks of staphylococcal food poisoning.

Prevention

All recommendations for the control of this disease have one objective: to prevent the staphylococci present in cooked protein food from forming enterotoxin. Attempts to keep food uncontaminated with staphylococci by cleanliness and isolation of food handlers appear doomed to failure because of the widespread presence of the organism. Consequently, effective points of attack lie in keeping cooked protein food at such temperatures that staphylococci cannot form enterotoxin, and limiting the length of time cooked protein food is kept at dangerous temperatures.

Segalove and Dack (*12*) reported the length of time and temperature necessary to produce enterotoxin in the laboratory. However, they state that much greater time is required to produce enterotoxin under laboratory conditions than is reportedly required to render food poisonous. Thus, their experiments are not strictly applicable for the control of this disease. In the absence of precise knowledge, these standards of temperatures and limits of time which may safeguard food have been chosen arbitrarily:

1. 40° F. is the maximum temperature for keeping cold, cooked protein food; 50° F. has been recommended but Evans and Niven (*13*) found that enterotoxigenic staphylococci grow well at this temperature. Segalove and Dack (*12*) showed that the rate of enterotoxin production was progressively retarded with lowering the temperature below 98.6° F. Since modern refrigerators may be adjusted with ease to temperatures of 40° F. and lower, this level appears advisable.

2. 140° F. is the minimum temperature for keeping hot cooked food since this is the reported thermal death point of staphylococci (*11*).

3. Three hours is the maximum length of time cooked protein food should be kept between 40° and 140° F., including the time required for chilling. This means the total cumulative time that food remains in this temperature range. The length of each exposure to temperatures 40°–140° F. must be added to that of all previous exposures when leftover food is involved.

While these recommendations are simple in principle, they are difficult in practice. Miller and Smull (*14*) reported that the quickest chilling of 1-gallon lots of potato salad requires 3 hours after being placed on beds of ice. Lewis and associates (*15*) recommended chilling food in shallow, flat pans rather than in deep containers; and Black and Lewis (*16*) recommended refrigerating food while hot. In the author's experience, the most rapid way of chilling food is to place it in flat, stainless steel pans in a freezing compartment rather than in the refrigerator. For example, it was found that the internal temperature of ½-gallon lots of potato salad was lowered from 65° to 41° F. within 35 minutes after being placed in the freezer at 14° F., while it required 80 minutes to lower the temperature of control lots from 65° to 46° F. after being placed in the refrigerator at 40°–44° F. Utilization of the freezing compartment of refrigerators appears the most effective way yet found to hurdle a major problem in controlling this disease—the delay in chilling cooked food.

In contrast to the difficulty in chilling food, rapid heating is relatively simple because of the large heat differential. In this survey and in the author's experience, inadequate heating of food usually arises from gross negligence—placing food in warm ovens; keeping food on a steamtable for many hours after the heat has been turned off; lowering the temperature of the steamtable because workers find its heat objectionable; mixing hot and cold items without subsequent heating, such as mixing cold chicken with hot cream sauce; warming leftover food rather than heating it thoroughly; and judging temperature of food by temperature of the water bath. In one instance the temperature of the water bath was 160° F., while that of the mass of food was 90° F.

There is often great discrepancy between the temperature of food and temperature of its environment, whether the environment be a water bath or refrigerator. Furthermore, the rate of chilling or heating food cannot be predetermined by sizes or types of containers or by mass of food, since the varied consistencies of food result in varied rates of heat conduction. Consequently, the only means of determining that food is adequately chilled is to insert a thermometer into the mass of food.

Certain problem foods should be handled with special precaution. If custard-filled puffs or eclairs are not to be consumed immediately after preparation, Stritar and associates (*17*) recommend rebaking them at 375° F. for 30 minutes, which these authors found sterilized the custard within the shell. Potato salad, chicken salad, egg salad, and similar items should not be used as leftovers since the 3-hour safe-time limit is usually consumed in preparing and serving. Foods containing bread or cracker crumbs, such as croquettes, meat loaf, and poultry dressing, pose a problem because the crumbs create air pockets and act as insulation against heating. Such foods should be prepared only for immediate consumption unless the temperature of the interior of the food has risen to more than 150° F. in cooking.

Sandwiches are common vehicles of staphylococcal food poisoning because they are frequently prepared well in advance of consumption and because chilling the filling of the sandwich, the crucial step, is impeded by the encasing bread acting as insulation. When sandwiches are not to be consumed immediately after preparation, the author suggests chilling them by placing them in layers of two in the freezer. Observations, reported in table 2, show that the filling of sandwiches cannot be adequately chilled when the sandwiches are stacked in three layers, even in freezers, but can be adequately chilled in 2 hours when sandwiches are stacked in two layers in a freezer.

Table 2. Rate of chilling ham filling in sandwiches refrigerated under various conditions

Temperature of refrigerator or freezer (degrees Fahrenheit)	Number of layers of sandwiches	Length of time (hours)	Fall of temperatures of ham filling [1] (degrees Fahrenheit)
38–40	3	2	78 to 61
38–40	2	2	78 to 53
38–40	1	2	78 to 49
8	3	2	76 to 58
8	2	2	83 to 34
8	2	1	83 to 52

[1] Ham filling in center sandwich if in 3 layers.

Finally, some well-known and commonly ignored precautions should be observed. Don't cook food well in advance of intended consumption. Don't forget leftovers, or assume that they are safe because they are in the refrigerator. Don't assume that the refrigerator supplies adequate chilling without testing the temperature. Refrigerator temperatures frequently are above 60° F. due to overloading, frequent opening of doors, or failure to adjust the cooling system so that the temperature remains constantly below 40° F. Don't mix hot and cold, cooked protein food without thorough heating afterward. Don't assume that boiling questionable food makes it safe to eat, since boiling does not destroy staphylococcus enterotoxin. Don't depend on odor, taste, or appearance of food to determine whether it is safe to eat since the staphylococcus enterotoxin is odorless, colorless, and tasteless (*9*). Whether cooked protein food is safe to eat or not can be determined only by the total length of time it has been exposed to temperatures between 40° and 140° F.

Summary and Conclusions

A survey of 95 outbreaks of staphylococcal food poisoning shows that the determining factour in the development of this disease lies solely in keeping cooked protein food warm or at room temperature for 4 hours or longer. Of 83 fully reported outbreaks, the vehicles in 95 percent were cooked protein food which was subsequently kept unrefrigerated or warmed, or both.

Contrary to currently accepted theory, it is clear that outbreaks commonly occur when the food is handled cleanly by personnel who are free of infections. The widespread presence of pathogenic staphylococci among healthy persons insures widespread contamination of food regardless of care in handling.

Therefore, recommendations for control of this disease have one objective: to prevent the staphylococci present in cooked protein food from forming enterotoxin.

In the absence of precise knowledge, the following standards were arbitrarily chosen to protect cooked protein food: 40° F. as the maximum temperature for keeping cold, cooked protein food; 140° F. as the minimum temperature for keeping hot, cooked protein food; 3 hours as the maximum length of time cooked protein food should be kept between 40° and 140° F.

REFERENCES

(*1*) Dauer, C. C., and Sylvester, G.: 1954 summary of disease outbreaks. Pub. Health Rep. 70: 536–544, June 1955.

(2) Dauer, C. C., and Sylvester, G.: 1955 summary of disease outbreaks. Pub. Health Rep. 71: 797–803, August 1956.

(3) Dauer, C. C., and Sylvester, G.: 1956 summary of disease outbreaks. Pub. Health Rep. 72: 735–742, August 1957.

(4) Dauer, C. C.: 1957 summary of disease outbreaks. Pub. Health Rep. 73: 681–686, August 1958.

(5) Allison, V. D.: Discussion on food poisoning. Proc. Royal Soc. Med. 42: 216–218, April 1949.

(6) Hussemann, D. L., and Tanner, F. W.: Comparison of strains of staphylococci isolated from foods. Food Res. 14: 91–97, March–April 1949.

(7) Saint-Martin, M., Charest, G., and Desranleau, J. M.: Bacteriophage typing in investigation of staphylococcal food-poisoning outbreaks. Canad. J. Pub. Health 42: 351–358, September 1951.

(8) Feig, M.: Diarrhea, dysentery, food poisoning and gastroenteritis. Am. J. Pub. Health 40: 1372–1394, November 1950.

(9) Dack, G. M.: Food poisoning. Ed. 3. Chicago, University of Chicago Press, 1956.

(10) Getting, V. A., Rubenstein, A. D., and Foley, G. E.: Staphylococcus and streptococcus carriers. Sources of food-borne outbreaks in war industry. Am. J. Pub. Health 34: 833–840, August 1944.

(11) Blair, J. E.: The staphylococci. *In* Bacterial and mycotic infections of man. Ed. 2. Philadelphia, J. B. Lippincott Co., 1952.

(12) Segalove, M., and Dack, G. M.: Relation of time and temperature to growth and enterotoxin production of staphylococci. Food Res. 6: 127–133, March–April 1941.

(13) Evans, J. B., and Niven, C. F., Jr.: A comparative study of known food-poisoning staphylococci and related varieties. J. Bact. 59: 545–550, April 1950.

(14) Miller, W. A., and Smull, M. L.: Efficiency of cooling practices in preventing growth of micrococci. J. Am. Dietet. A. 31: 469–473, May 1955.

(15) Lewis, M. N., Weiser, H. H., and Winter, A. R.: Bacterial growth in chicken salad. J. Am. Dietet. A. 29: 1094–1099, November 1953.

(16) Black, L. C., and Lewis, M. N.: Effect on bacterial growth of various methods of cooling cooked foods. J. Am. Dietet. A. 24: 399–404, May 1948.

(17) Stritar, J., Dack, G. M., and Jungewalter, F. G.: Control of staphylococci in custard-filled puffs and eclairs. Food Res. 1: 237–246, May–June 1936.

Summer Session in Health Statistics

Statistics in the health sciences will be the subject of the 1960 graduate summer session, June 16 to July 30, 1960, sponsored by the accredited Schools of Public Health of the United States.

The University of Minnesota School of Public Health at Minneapolis is the host. The session will be held under a research training grant from the Division of General Medical Sciences of the National Institutes of Health, Public Health Service.

Courses offered will include: statistical methods in public health; management of health agency records; biostatistics in the health sciences; demographic methods in public health; registration and vital records; advanced biostatistics in the health sciences; statistical methods in epidemiology; sampling techniques in the health sciences; statistical methods in biological assay; and a lecture series.

A limited number of fellowships are available. Information may be obtained by writing to Professor J. E. Bearman, Biostatistics Division, University of Minnesota, Minneapolis 14, Minn.