Diarrhea, Dysentery, Food Poisoning, and Gastroenteritis

A Study of 926 Outbreaks and 49,879 Cases Reported to the United States Public Health Service (1945–1947)

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THE past decade has witnessed a marked revival of interest in gastrointestinal diseases of bacterial origin, which follows a lull initiated by our conquest of typhoid and other enteric fevers as a major public health problem. Although typhoid and its related fevers have decreased in incidence to a point of comparative disappearance, there has been a seemingly progressive rise among vaguer epidemic groups of bacterial enteric disease involving ever-increasing numbers of our population.[1] Clinically and epidemiologically, these groups have been overlapping and confusing, but recent bacteriologic contributions have provided the tools for further progress in the clarification and control of the problem. The discovery of staphylococcal enterotoxin and its role in the production of gastroenteritis, and the recognition and identification of the many species of salmonellae, as well as their distribution in nature, are responsible for this stimulation of interest.

Criticism has been directed toward health agencies for their failure to require the reporting of the hitherto less-recognized bacterial gastrointestinal diseases, and for limiting reporting to "outbreaks" only.[2] It is also suggested that improper and no longer valid diagnostic terminology is employed in those few instances where reporting is required. There can be no doubt that a confusion in terminology can lead only to a confusion in the appraisal of facts. Yet it must be appreciated that the requiring of reporting, and official changes in terminology alone, are inadequate. The practitioner and clinician must reorient their thinking away from the established habitual diagnoses such as "diarrhea, dysentery, and food poisoning," which, in almost all instances, are based on vague non-differential symptomatology, and toward a less-confusing and less-overlapping etiological classification.

In essence, this paper is a study of reports of gastrointestinal disease outbreaks made to the U. S. Public Health Service for the years 1945–1947. These reports are compiled annually by the Milk and Food Branch of the Division of Sanitary Engineering, and are printed in the form of master tables. They comprise the source for the data presented here, and have been studied with reference to the interrelated disease groups mentioned in the preceding paragraph. Emphasis is placed upon the need for a diagnostic terminology based on etiology, the causative organisms involved in these outbreaks, and the relative frequency of such involvement, the incubation periods, vehicles of transmission, seasonal variation, and fatality rates.

DIAGNOSTIC TERMINOLOGY

In the master tables under consideration in this paper, one finds four diagnostic groups—diarrhea, dysentery, food poisoning, and gastroenteritis—as reported to the U.S.P.H.S. by various state and city health departments. These are also terms frequently used in diagnosis by the clinician. Diarrhea is purely a symptomatic term; dysentery is almost synonymous (with usage tending to confine it to association with diarrhea caused by shigellae or amebae); gastroenteritis is an anatomical description of disease which embraces the first two terms, plus at times the additional symptomatology of nausea and vomiting; and food poisoning embraces all three of the previous diagnoses, with some reference to a vehicle for transfer of the causative agent. Increasing knowledge frequently enables us to take what previously had been considered a single clinical picture, albeit vague, and distinguish two or more distinct entities. Occasionally, the opposite occurs, and what have been considered two unrelated disease entities are subsequently shown to be part of but a single picture. It thus becomes necessary to reëvaluate these four diagnostic terms.

One factor which may determine the diagnostic appellation used may be the vehicle of transmission which is held responsible for the particular outbreak. That this is true in a negative fashion may be gathered from the fact that where water is the vehicle in a bacterial gastroenteric disease outbreak, the disease is never called food poisoning but gastroenteritis—obviously due to reluctance to consider water a food (Table 1). (Yet for some inexplicable reason water-borne *chemical* gastroenteritis is *always* called food poisoning.) Where milk and milk products are concerned as vehicles we find a more equitable diagnostic distribution of these two terms. There is apparent also a reluctance to use " diarrhea " as a diagnosis for outbreaks transmitted by these products. Not once was it employed in this respect in the 16 outbreaks which occurred during the three year period under consideration—this despite the fact that " infant diarrheas " were included in this tabulation. The writer has no inkling why this should be so. On the positive side is noticed the tendency, in water-borne gastroenteric disease outbreaks of undetermined etiology, to employ a diagnosis of gastroenteritis as opposed to diarrhea or dysentery (in 55 of 60 outbreaks) (Table 2).

Table 2 represents an effort to determine whether any relationship exists between the diagnostic term used and the determination of etiology for the outbreak. It will be noted that, for the disease " diarrhea," in only 2 of 16 out-

TABLE 1

Distribution by Diagnosis of 987 Outbreaks of Bacterial Gastroenteric Diseases according to Vehicle of Transmission (1945–1947)

Diagnosis	*Water Outbreaks*		*Milk and Milk Products Outbreaks*		*Foods Other than Milk and Milk Products Outbreaks*		*Vehicle Undetermined Outbreaks*		*Total Outbreaks*	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Diarrhea	4	4.9	–	–	9	1.1	3	6.8	16	1.6
Dysentery	3	3.7	2	3.7	7	0.9	2	4.5	14	1.4
Food Poisoning	–	–	26	48.2	518*	64.2	7	15.9	551	55.9
Gastroenteritis	57	70.4	18	33.2	246	30.4	24	54.5	345	35.0
Paratyphoid	–	–	1	1.9	4	0.5	1	2.3	6	0.6
Typhoid	17	21.0	7	13.0	24	3.0	7	15.9	55	5.6
Totals	81	100.0	54	100.0	808	100.1	44	99.9	987	100.1

* Does not include 13 outbreaks due to mushroom poison.

TABLE 2

Diagnostic Distribution of 926 Outbreaks of Gastroenteric Diseases according to Vehicle of Transmission and Determination of Etiology (1945–1947)

	Water		Milk and Milk Products		Foods Other Than Milk Products		Vehicle Undetermined		Total		
Diagnosis	*Probable Etiology Determined*	*Etiology Undetermined*	*Probable Etiology Determined*	*Etiology Undetermined*	*Probable Etiology Determined*	*Etiology Undetermined*	*Probable Etiology Determined*	*Etiology Undetermined*	*Probable Etiology Determined*	*Etiology Undetermined*	*Total*
Diarrhea	1	3	0	0	1	8	0	3	2	14	16
Dysentery	1	2	2	0	7	0	0	2	10	4	14
Food Poisoning	0	0	19	7	297*	221	3	4	319	232	551
Gastroenteritis	2	55	12	6	128	118	3	21	145	200	345
Totals	4	60	33	13	433	347	6	30	476	450	926

* Does not include 13 outbreaks due to plant or mushroom poison.

breaks was the probable etiology determined; that, for the disease "food poisoning," the probable etiology was determined bacteriologically in only 319 of 551 outbreaks (58 per cent); and for "gastroenteritis" in 145 of 345 outbreaks (42 per cent). Only in the case of "dysentery" was there adequate bacteriologic evidence (in 10 of 14 outbreaks) which might lend support to a definite diagnosis. It seems evident, therefore, that with the exception of "dysentery" the terms used as diagnoses in gastroenteric disease outbreaks are not based upon etiology.

A third factor which may enter into the choice of one of the above terms for diagnostic purposes may be the clinical picture of the illness in the patient or the epidemiological pattern which may present itself to the epidemiologist. The author is not aware of any remotely acceptable differentiation along either of these two lines between the four diseases as presented here, and as accepted for reporting to official health agencies at present.

INCIDENCE

Inadequate as our present diagnostic nomenclature is, there are many factors besides terminology which have operated against our securing any approximate estimate of the incidence of the bacterial gastrointestinal syndromes considered here. But a failure to secure a reasonable approximation of the *absolute* incidence does not necessarily mean that no information of any value is obtainable from the data on hand. Information concerning the *relative* incidence of these disease groups to each other, of the relative frequency of the major vehicles of contamination involved in these outbreaks, of the relative frequency of involvement of various bacterial groups and the major food items implicated with them, can be of value in a public health approach toward a proper evaluation of the problem, and as a guide toward the establishment of diagnostic criteria and preventive measures.

In the diagnostic categories with which this paper is concerned, and during the three year period under study, there were reported 987 outbreaks involving 50,819 persons (Table 1). Of these, the enteric fevers (typhoid and paratyphoid) constituted 61 outbreaks (6.1 per cent) and 940 persons (1.8 per cent). The remaining outbreaks and cases are represented by the diarrhea-dysentery-food poisoning-gastroenteritis groups.

Of the 61 enteric fever outbreaks, milk and milk products were responsible for the lowest number (8), and in a similar number the vehicle could not be determined. Water was the vehicle in 17 of the outbreaks, and foods other than milk and milk products were responsible for the greatest number—28 or 46 per cent (Table 1).

Where the etiology of the 14 dysentery outbreaks was established, in every instance except one the responsible organism was a member of the Shigella genus (Table 5). The method of dissemination of these organisms seems to parallel that of the enteric fevers, milk and milk products being responsible for 2 of the outbreaks, water for 3, and foods other than milk and its products for 7 (50 per cent) (Table 1). Three thousand and fifty-five cases were involved in the 14 outbreaks (Table 3).

than one-third of the states. Those who wish to use the data presented here to compare the relative incidence of typhoid-paratyphoid infection with that of the other group of bacterial gastrointestinal diseases must take into consideration two important factors—the greater population covered in the reporting of enteric fevers, and the greater tendency among physicians to report these diseases as compared with the second type. Thus, the ratio of the second group to the enteric fever group will not be 15 to 1 for the number of outbreaks or 50 to 1 for the number of cases involved, but will be several times these figures when population ratios are adjusted and allowances made for greater accuracy in reporting.

TABLE 3

Incidence of Diarrhea, Dysentery, Food Poisoning, and Gastroenteritis, Typhoid and Paratyphoid Fevers, in the United States (1945–1947) *

	Diarrhea		*Food Poisoning and Gastroenteritis*		*Dysentery*		*Typhoid and Paratyphoid*		*Totals*	
Year	*Out-Breaks*	*Cases*	*Out-Breaks*	*Cases*	*Out-Breaks*	*Cases*	*Out-Breaks*	*Cases*	*Out-Breaks*	*Cases*
1945	6	589	268	13,158	4	314	28	467	306	14,528
1946	5	423	301	13,221	5	2,640	11	117	323	16,401
1947	5	3,665	327	15,782	5	87	22	356	358	19,890
Totals	16	4,677	896	42,161	14	3,055	61	940	987	50,819

* Does not include 13 outbreaks (62 cases) of plant and mushroom poisoning.

Sixteen outbreaks of "diarrhea" were reported. The number of cases involved was 4,677 (Table 3). Unlike the dysentery outbreaks, however, the term used for diagnosis depended entirely upon the whim of the reporting physician and agency, the etiological agents having been determined in but 2 of the 16 outbreaks. Milk and milk products were implicated in none of them, 4 being transmitted by water and 9 by foods other than milk and milk products.

It should be noted at this point, that typhoid and paratyphoid fevers are reportable in all states of the United States, but that the other diseases considered here are reportable in no more

Attention must be focused on those outbreaks labeled as food poisoning and gastroenteritis. These numbered 896 of the 926 outbreaks considered in Table 2, and involved 42,161 of the 49,879 cases in the group under primary consideration—i.e., 97 per cent and 85 per cent respectively (Table 3). About 300 such outbreaks are reported each year from no more than 16 states. The rise in number from 268 in 1945 to 327 in 1947 has no statistical significance for this period of time—neither has the slight rise in number of cases involved per annum. The disproportion in the relationship between the percentage of total outbreaks and cases mentioned here is due to the fact that a single "dysentery"

TABLE 4

*Incidence of 926 Outbreaks of Diarrhea, Dysentery, Food Poisoning, and Gastroenteritis (1945–1947) by Month of Year, and Major Vehicle of Transmission **

Vehicle	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Water	3	2	2	2	5	4	26[a]	9	4	5	0	1	63
Milk and Milk Products	3	3	7	7	3	1	6	4	6	5	2	0	47
Other Foods	60	51	51	57	71	73	82	70	65	79	68	53	780
Total	66	56	60	66	79	78	114	83	75	89	70	54	890
Unknown Vehicles	0	3	1	3	1	2	6	7	3	4	5	1	36

* Does not include 13 outbreaks of plant or mushroom poisoning.
[a] Distributed annually as follows: 1945, 6; 1946, 10; 1947, 10.

outbreak in 1946 was water-borne and totaled more than 2,000 cases, and a water-borne "diarrhea" outbreak involved more than 3,000 cases. Foods other than milk and milk products are responsible as vehicles for almost 86 per cent of the food poisoning and gastroenteritis outbreaks, as compared with about 50 per cent in the diarrhea and dysentery groups.

Table 4 represents an effort to determine the influence of the vehicle of transmission on the seasonal variation. In all groups the incidence of disease outbreaks is less during the colder winter months than during the hotter months. It is worth notice that more than half the water-borne outbreaks occur during the months of July and August, with July predominating overwhelmingly. No valid reason for this can be ascribed by the writer. Early spring to fall represents a plateau for the increase in outbreaks carried by milk and milk products. It is not believed that the drop in May and June has any specific significance. While the disease outbreaks carried by foods other than milk or milk products show a tendency toward increased incidence during the warmer months than the colder ones, the relatively high number of outbreaks occurring throughout the year is worthy of attention inasmuch as the belief is commonly prevalent that such outbreaks are comparatively infrequent and rare in winter. Apparently, nothing could be further from the truth, and the danger from relaxation of preventive measures in the control of these outbreaks during the colder months is emphasized.

ETIOLOGY

Of the 926 outbreaks in the four gen-

TABLE 5

Bacteria Involved in 476 Outbreaks (1945–1947) of Gastrointestinal Disease Reported as Diarrhea, Dysentery, Food Poisoning, Gastroenteritis

	319 Food Poisoning Outbreaks		145 Gastroenteritis Outbreaks		2 Diarrhea Outbreaks		10 Dysentery Outbreaks		476 Total Outbreaks	
Bacteria	No.	%	No.	%	No.	%	No.	%	No.	%
Staphylococci	263	82.2	104	71.8	..	.	1	10.0	368	77.7
Salmonellae	40	12.5	32	20.6	..	..	..	..	72	14.9
Streptococci	24	7.5	10	6.9	..	..	..	..	34	6.9
Shigellae	2	0.6	2	1.4	1	50.0	9	90.0	14	2.9
E. coli	5	1.6	4	2.8	1	50.0	..	..	10	2.1
A. aerobacter	4	1.2	0	..	..	..	..	..	4	0.8
Proteus vulgaris	3	0.9	1	0.7	..	..	..	..	4	0.8
Miscellaneous	2	0.6	3	2.1	..	..	..	..	5	1.0
Totals	343	..	156	..	2	..	10	..	511	..

eral groups under consideration, the bacterial excitant was determined in 478 (Table 5). In some instances two or more unrelated bacteria were isolated. In most instances no information was available as to the source—whether ingested food, vomitus, feces, urine, or blood.

A glance at Table 5 will reveal that with the exception of the dysentery outbreaks, all the bacterial groups were involved regardless of the diagnosis used. Since the bacterial excitant was isolated in only two diarrhea outbreaks, the discussion again resolves itself into a consideration of "food poisoning" and "gastroenteritis."

In order of frequency the bacteria involved in two or more of these outbreaks are: staphylococci, salmonellae, streptococci, coli, shigellae, aerobacter, and *Proteus vulgaris*.

Staphylococci

Staphylococci were implicated in 368 (78 per cent) of all outbreaks—in 82 per cent of the 320 food poisoning outbreaks and 72 per cent of the 146 gastroenteritis outbreaks of known etiology. Only once were they isolated from an outbreak classed as dysentery, and not even once from the "diarrhea" group. The 368 outbreaks involved 14,988 cases (Table 6). Staphylococci caused 5 times as many outbreaks and involved more than 4 times as many patients as the next most frequent group, the salmonellae. Milk and milk-products acted as vehicles for transmission 22 times, and other foods 345 times. Twenty-four (6.5 per cent) of the outbreaks also showed

TABLE 6

Bacteria Involved in 476 Outbreaks of Gastroenteric Disease (1945–1947)

Organism	Total No. of Outbreaks Involved	Total No. of Cases	Vehicles of Transmission for Outbreaks			
			Water	Milk and Milk Products	Other Foods	Unknown
STAPHYLOCOCCI	368	14,988	0	22	345	1
SALMONELLA	72	3,430	0	8	60	4
Group and Species unspecified	26	1,042	–	3	20	3
Group C-Species unspecified	4	122	–	–	4	–
S. typhimurium	16	923	–	4	11	1
S. newport	7	807	–	–	7	–
S. oranienburg	4	65	–	–	4	–
S. montevideo	4	145	–	–	4	–
S. aniegar	2	16	–	–	2	–
S. newington	2	18	–	–	2	–
Others (7)[a]	7	292	–	1	6	–
STREPTOCOCCI	34	1,157	0	2	32	0
Type unspecified	18	341	–	–	17	–
Hemolytic	2	88	–	1	1	–
Hemolytic alpha	2	405	–	–	2	–
Non-hemolytic	2	125	–	–	2	–
S. fecalis	5	122	–	1	4	–
S. viridans	5	76	–	–	5	–
SHIGELLA	14	2,883	2	2	9	1
Species unspecified	1	15	–	–	1	–
S. paradysenteriae	9	2,646	2	2	5	–
S. sonne	3	215	–	–	2	1
S. alkalescens	1	7	–	–	1	–
E. coli	10	302	1	1	8	–
Proteus vulgaris	4	78	–	–	4	–
A. aerogenes	4	52	–	–	4	–
Miscellaneous *	5	819	1	1	3	–
Undetermined	450	19,196	55	13	349	24

[a] *S. copenhagen, S. derby, S. cholerae-suis, S. enteritidis, S. thompson, S. manhattan, S. panama*

* *Pseudomonas Aeruginosa*, Gram-neg. bacilli, Gram-neg. spore-bearer, *B. paracolon, B. fecalis alcaligenes*

TABLE 7

Nature of Mixed Infections in 476 Outbreaks of Four Groups of Gastrointestinal Disease (Diarrhea, Dysentery, Food Poisoning, Gastroenteritis)

Type of Bacteria	*(476) Total Number of Outbreaks Involved in*	*(33) Outbreaks With Mixed Infection* No.	%	*Other Bacteria Involved*
Staphylococci	368	24 *	6.5	17 Strep., 3 Sal., 2 Aerog., 1 Coli [a]
Salmonella	72	6	8.3	3 Staph., 2 Strep., 1 Mixed Sal.
Streptococci	34	21 *	61.8	17 Staph., 2 Sal., 1 Aerog.[a]
Shigella	14	0	0.0	—
E. Coli	10	5 *	50.0	2 *Prot. Vul.*, 1 Staph., 1 Aerog.
Prot. vulgaris	4	3 *	75.0	2 Coli [a]
A. aerogenes	4	4	100.0	2 Staph., 1 Strep., 1 Coli
Miscellaneous	5	0	0.0	—

* Includes 1 outbreak containing Staph., Strep., Coli, *Prot. vulg.*
[a] Does not include 1 outbreak containing Staph., Strep., Coli, *Prot. vulg.*

other bacterial contaminants—streptococci in 17 instances and salmonellae in 3 (Table 7). While outbreaks due to staphylococci tend to increase during summer and early fall, and fall to a minimum in winter, nevertheless the incidence of such outbreaks during the colder months is much higher than expected (Table 9). The more frequent food items involved in the transmission of these organisms will be discussed later in this paper.

Salmonellae

These organisms seem to follow the same pattern of diagnostic distribution as the staphylococci. Of 72 outbreaks totaling 3,430 cases caused by salmonellae, 40 were termed food poisoning and 32 gastroenteritis. This represents one-fourth to one-fifth the reported incidence of the staphylococcic outbreaks (Table 5). Of the 72 outbreaks, 8 were carried by milk and milk products and 60 by other foods—the vehicle could not be determined in 4 outbreaks (Table 6). In 30 of the outbreaks (42.5 per cent) the species was not determined, but in 4 of these the Kauffman-White group classification was determined as Group C. Of the 42 species which were identified, by far the most frequent was *S. typhimurium*—in 16 outbreaks; second was *S. newport*—in 7 outbreaks; followed by *S. oranienburg* (4), *S. montevideo* (4), and *S. aniegar* and *S. newington* with 2 outbreaks each. In 7 outbreaks 7 other species were involved (Table 6).

Six of the 72 outbreaks (8 per cent) revealed the presence of mixed contamination; in 3 instances with staphylococci and in 2 with streptococci. One outbreak showed two different species of salmonella.

These outbreaks are susceptible to greater seasonal variation than the staphylococcal outbreaks, the highest incidence being reached during the summer months, and the lowest incidence during winter (Table 8).

The Streptococci

Thirty four outbreaks during the three year period may be attributed to streptococci. The pattern of diagnostic terminology follows that of the staphylococci and salmonellae—24 of the outbreaks being called food poisoning and 10 called gastroenteritis (Table 5). In either case, streptococci may be held responsible for about 7 per cent of all the outbreaks in each group. These outbreaks affected 1,157 individuals—having a relative frequency about one-eleventh that of the staphylococci, and almost half the

TABLE 8

Incidence of 897 Outbreaks of Diarrhea, Dysentery, Food Poisoning and Gastroenteritis (1945–1947) by months of year, and attributed etiology

Attributed Etiology	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Total*
Staphylococci	25	24	23	28	26	32	41	38	32	41	17	18	345
Salmonella	1	2	6	5	6	9	11	6	7	4	8	2	67
Streptococci	2	–	2	1	2	1	–	–	1	1	1	2	13
Shigella	1	1	--	2	1	1	–	–	1	3	–	3	13
E. coli	1	–	–	1	–	–	–	–	–	1	–	2	5
Miscellaneous	–	–	–	2	1	1	1	–	–	–	1	–	6
Mixed	5	2	1	2	2	4	1	1	–	1	2	4	25
Unknown	31	27	28	25	41	30	62	38	36	39	43	23	423
Totals	66	56	60	66	79	78	116	83	77	90	72	54	897

frequency of the salmonella outbreaks. Relative case frequency is about one-fourteenth that of the staphylococci and one-third that of the salmonellae. An important aspect of the above consideration is that 62 per cent of the outbreaks showed the presence of other bacteria (Table 6). Of the 21 outbreaks with mixed contamination, 17 were with staphylococci and 2 with salmonellae (Table 7). Thus, if the streptococci are to be considered as secondary contaminants, with a very questionable etiologic role in these outbreaks, the relative incidence must be little better than a third of the previous estimation. Exact identification of the streptococcus involved was obtainable in 10 of the outbreaks, 5 being attributable to *Streptococcus fecalis* and 5 to *Streptococcus viridans*. Two outbreaks were attributed to unspecified hemolytic alpha strains, and 2 to non-hemolytic strains. No estimate of the seasonal variation of these streptococcus - caused outbreaks is of value because of inadequate information. The seasonal incidence for 13 outbreaks is itemized in Table 8. Of the 34 outbreaks, milk or milk products were the vehicle of transmission in 2, and other foods in 32.

The Shigellae

Shigellae were isolated in 14 of the 478 outbreaks in Table 5. Of the 10 dysentery outbreaks, 9 were due to shigellae and 1 to staphylococci. Of the 5 remaining shigella-caused outbreaks, two each were called food poisoning and gastroenteritis, and one was labeled diarrhea. These 14 outbreaks involved 2,883 individuals (Table 6). In not a single outbreak was a second organism found (Table 7). *S. paradysenteriae* were identified in 9 outbreaks, *S. sonnei* in 3, and *S. alkalescens* in 1 (Table 6). Shigella-caused outbreaks were reported one-nineteenth as frequently as staphylococcal outbreaks and one-fifth as frequently as salmonella. Shigella outbreaks, however, produced one-fifth as many patients as did the staphylococcic, and almost as many cases as the salmonellae-caused outbreaks. These relative frequencies must be modified in order to obtain a more approximate index of relative incidence, inasmuch as shigella-caused disease is reportable in all states, and so comparisons will be three to five times less when adjusted on a population basis.

Of the 14 reported outbreaks, 2 each were transmitted by water and milk or milk products, and 9 by other foods (Table 6).

Seasonal variation in the incidence of shigella-caused outbreaks is noted in Table 8. Too few outbreaks are recorded to draw any conclusions.

TABLE 9

Incubation Periods of 295 Bacterial Outbreaks (14,663 cases) of Definitely Determined Etiology

Incubation In Hours	Staphylococci Outbreaks No.	Staphylococci Outbreaks Cumulative %	Staphylococci Cases No.	Staphylococci Cases Cumulative %	Salmonella O-B No.	Salmonella Cases No.	Shigella O-B No.	Shigella Cases No.	Streptococci O-B No.	Streptococci Cases No.	E. Coli O-B No.	E. Coli Cases No.
UNDER 1	–	–	–	–	–	–	–	–	–	–	–	–
1–1.9	10	4.3	132	1.4	1	400	–	–	–	–	–	–
2–2.9	30	17.4	2619	31.5	1	3	–	–	–	–	1	30
3–3.9	76	50.5	2274	55.3	–	–	–	–	2	90	–	–
4–4.9	45	70.0	1363	70.4	1	1	–	–	2	6	–	–
5–5.9	15	79.0	764	78.8	–	–	–	–	–	–	1	2
6–6.9	12	81.8	173	80.7	1	6	–	–	–	–	–	–
7–7.9	10	86.0	268	83.6	–	–	–	–	1	34	–	–
8–8.9	6	88.8	124	85.0	1	88	–	–	1	5	–	–
9–9.9	6	91.4	188	87.0	1	40	–	–	1	74	1	6
10–10.9	8	95.0	708	94.9	5	53	–	–	–	–	–	–
11–11.9	2	95.7	121	95.9	1	16	1	7	–	–	1	9
12–12.9	3	97.0	138	97.7	3	122	–	–	–	–	–	–
13–13.9	–	–	–	–	1	33	–	–	–	–	1	195
14–14.9	2	97.8	60	98.4	3	104	–	–	1	400	–	–
15–15.9	–	–	–	–	–	–	–	–	1	20	–	–
16–16.9	1	98.4	12	98.5	2	50	–	–	–	–	–	–
17–17.9	1	98.9	20	98.7	1	120	–	–	–	–	–	–
18–18.9	1	99.3	109	99.8	2	107	–	–	–	–	–	–
19–19.9	–	–	–	–	4	167	–	–	–	–	–	–
20–20.9	–	–	–	–	2	247	–	–	–	–	–	–
21–21.9	–	–	–	–	–	–	–	–	–	–	–	–
22–22.9	–	–	–	–	–	–	–	–	–	–	–	–
23–23.9	–	–	–	–	–	–	–	–	–	–	–	–
24–35.9	1	99.6	5	99.9	6	296	1	22	–	–	–	–
36–47.9	–	–	–	–	5	110	1	90	–	–	–	–
48–59.9	1	100.0	6	100.0	4	321	2	2273	–	–	–	–
60–71.9	–	–	–	–	–	–	–	–	–	–	–	–
72–83.9	–	–	–	–	–	–	1	32	–	–	–	–
84+	–	–	–	–	–	–	–	–	–	–	–	–
Totals	230		9084		45	2284	6	2424	9	629	5	242
Medians	3.9		3.8		18.2	17.9	42.0	53.4	6.0	10.3	9.5	11.7
Interquartile Range	3.1–5.7		2.9–5.6		10.2–22.9	11.3–27.5	–		–			

NOTE: There was no significant variation in either incubation periods or ranges of the various species of salmonella from that of the entire group.
O-B = Outbreaks.

E. coli

These organisms may be considered causative agents in 10 (2 per cent) of the outbreaks, 5 of which were called food poisoning, 4 gastroenteritis and 1 diarrhea (Table 5). In these outbreaks 302 individuals became ill (Table 6), and in 5 of the 10 outbreaks other organisms were also isolated—twice with *Proteus vulgaris,* once with staphylococci, once with *A. aerogenes,* and once with 3 other groups (Table 7). The same problem, therefore, presents itself in estimating the relative incidence as in the case of streptococcal outbreaks. We may roughly judge outbreaks due to *E. coli* as one-seventh to one-fourteenth as frequent as salmonella outbreaks and one-fiftieth to one-hundredth as frequent as staphylococcus outbreaks. Of these 10 outbreaks, water was considered the vehicle in one, milk or milk products in a second, and other foods in 8.

Proteus vulgaris

Proteus vulgaris was isolated in 4 outbreaks, 3 of which were termed food poisoning, and the fourth gastroenteritis (Table 5). Seventy-eight cases were recorded in these outbreaks (Table 6). Three of the 4 outbreaks showed mixed contamination, 2 with *E. coli* and 1 with several organisms (Table 7).

Aerobacter aerogenes

A. aerogenes was involved in 4 outbreaks totaling 52 cases (Table 6). All 4 outbreaks were labeled food poisoning. Since all the outbreaks showed the presence of other organisms as well (Table 7), it is inadvisable to evaluate the role of *A. aerogenes* as a causative factor at present.

Outbreaks of Undetermined Etiology

Outbreaks for which no etiology could be determined constitute so high a proportion that attention must be focused upon them. In 450 of 926 outbreaks (49 per cent), no bacterial cause could be found. It has already been shown that, with the exception of dysentery, there was no relationship between the diagnosis used to define the outbreak and the etiology. The outbreaks which lend themselves best to bacteriologic study are those transmitted by milk and milk products—the etiology having been determined in 72 per cent. The poorest of the group are those transmitted by water, the etiology being determined in only 6 per cent of all water-borne disease outbreaks.

INCUBATION PERIODS

Since, with the possible exception of dysentery, the other diagnoses permit of no differentiation, and with the ever-increasing recognition of the need for a differentiation based on etiology, the incubation periods were determined for the five commonest bacterial groups involved in these outbreaks. The mean incubation period was determined for those outbreaks in which such periods were reported. In order to decrease the possibility of error, those outbreaks were omitted from our tabulation in which the etiology was expressed as "possibly" or "probably" or qualified by a question mark (?) in the reports studied.

The incubation periods are tabulated in Table 9 and represent 295 bacterial outbreaks involving 14,663 cases. The median incubation periods were determined for each bacterial group, both by outbreak and case distribution.

The median incubation period for 230 staphylococcic outbreaks was 3.9 hours, and for the 9,084 cases was 3.8 hours. The interquartile ranges were 3.1–5.7 and 2.9–5.6 hours respectively.

For 45 salmonella outbreaks the median incubation period was 18.2 hours, and the median for 2,284 cases was 19.9 hours. The interquartile ranges for each group were 10.2–22.9 hours and 11.3–27.5 hours respectively.

In the 6 shigella outbreaks, comprising a total of 2,284 cases for which incubation periods were stated, the medians were 42.0 hours for the outbreaks and 53.4 hours as determined by case distribution.

Nine outbreaks attributed to streptococci showed an incubation period median of 6 hours, and for the 629 cases involved, the median was 10.3 hours.

For 5 *E. coli* outbreaks involving 242 patients the median for the outbreaks was 9.5 hours, and for the cases 11.7 hours.

The outbreaks of known etiology were regrouped to show their distribution at various incubation period levels (Table 10). Of 210 such outbreaks in which the incubation periods were less than 8 hours, 198 were due to staphylococci. This represents 94.3 per cent of the group. 95 per cent of all staphylococcic outbreaks occurred within 11 hours of the ingestion of the contaminated food (Table 9). Only 4 (3 per cent) of the 210 outbreaks which occurred during the 8 hour incubation interval were due to salmonellae, but there is a steady increase in the distribution of salmonellae outbreaks at the later incubation intervals so that at 16–60 hours they are responsible for 26 of 35 outbreaks (74 per cent) of known etiology occurring during this period. The 9 outbreaks attributed to streptococci and the 5 attributed to *E. coli* seem evenly distributed among the incubation period groups ranging from 0 to 16 hours. Of the shigella caused outbreaks (6), with the exception of 1, the incubation periods were fairly equitably distributed within 1–4 days, and constituted a continuously higher percentage of all outbreaks of known etiology which occurred during this interval.

VEHICLES OF TRANSMISSION

For those who may be interested in the annual incidence of outbreaks and the type of contaminated vehicle involved, Table 11 is presented. Since staphylococci have been shown to be responsible for most outbreaks in which the bacterial agent was determined, these outbreaks were tabulated separately. The general information which may be gathered from this table has been mentioned at other points in this article. Worthy of emphasis is the picture presented by water-borne outbreaks, in that, only in the extreme minority of instances, are the responsible bacteria found, and the ever-present danger of widespread dissemination of disease through this vehicle to which the greatest number of the population is exposed (16,408 cases in only 64 outbreaks).

Table 12 shows the frequency of involvement of the contaminated vehicles, broken down into specific food items, in 392 bacterial gastroenteric disease outbreaks which were reported in the four groups under study, and distributed according to etiology. Where more than one contaminated vehicle was mentioned as responsible, each item was credited accordingly. Where a single contaminated vehicle was mentioned which could be reduced to two or more of the food items listed in the table, it was so done.

There were 378 food items involved in 304 staphylococcic outbreaks. The five most common food groups which were implicated are:

1. Meat products—35.5 per cent of the out-outbreaks
2. Bakery products—35.3 per cent of the outbreaks
3. Poultry—22.0 per cent of the outbreaks
4. Potatoes—8.6 per cent of the outbreaks
5. Milk or milk products—6.6 per cent of the outbreaks

Of the meat products, ham was the greatest single offender (in 50 of 108 outbreaks). Pork and tongue were responsible for no greater proportion of the outbreaks than any of the other meats and so were not itemized separately. Of the bakery products, cream and custard pastries were implicated in 92 of 107 outbreaks (86 per cent). The distribution of involved poultry prod-

TABLE 10

Distribution of 297 Outbreaks of Known Etiology at Various Incubation Period Intervals in Hours

Organism	*0–3.9*		*4–7.9*		*8–11.9*		*12–15.9*		*16–19.9*		*20–23.9*		*24–35.9*		*36–47.9*		*48–59.9*		*60–71.9*		*72–83.9*		*Total*	
	Number of O-B	*Per Cent of Interval Total*	*Number of O-B*	*Per Cent of Interval Total*	*Number of O-B*	*Per Cent of Interval Total*	*Number of O-B*	*Per Cent of Interval Total*	*Number of O-B*	*Per Cent of Interval Total*	*Number of O-B*	*Per Cent of Interval Total*	*Number of O-B*	*Per Cent of Interval Total*	*Number of O-B*	*Per Cent of Interval Total*	*Number of O-B*	*Per Cent of Interval Total*	*Number of O-B*	*Per Cent of Interval Total*	*Number of O-B*	*Per Cent of Interval Total*	*Number of O-B*	*Per Cent of Interval Total*
Staphylococci	116	95.2	82	93.3	22	62.8	5	31.2	3	25.0	0	–	1	12.5	0	–	1	14.3	0	–	0	–	230	77.4
Salmonella	2	1.6	2	2.3	8	22.9	7	43.8	9	75.0	2	100	6	75.0	5	83.3	4	57.1	0	–	0	–	45	15.2
Streptococci	2	1.6	3	3.4	2	5.7	2	12.5	0	–	0	–	0	–	0	–	0	–	0	–	0	–	9	3.0
Shigella	0	–	0	–	1	2.8	0	–	0	–	0	–	1	12.5	1	16.7	2	28.6	0	–	1	100.0	6	2.0
E. coli	1	0.8	1	1.1	2	5.7	1	6.3	0	–	0	–	0	–	–	–	0	–	0	–	–	–	5	1.7
Miscellaneous*	1	0.8	0	–	0	–	1	6.3	0	–	0	–	0	–	0	–	0	–	0	–	0	–	2	0.7
Total	122	100.0	88	100.1	35	99.9	16	100.1	12	100.0	2	100.0	8	100.0	6	100.0	7	100.0	0	–	1	100.0	297	100.0

* Includes *B. faecalis alcaligenes*, and Gram-neg. spore-bearer

TABLE 11

Incidence of Outbreaks and Cases Attributable to Staphylococci, Other Bacteria and Undetermined Causes According to Vehicle Involved (1945–1947)

		VEHICLE									
		Water		*Milk*		*Other Foods*		*Vehicle Unknown*		*Totals*	
Organism	*Year*	*Out-Breaks*	*Cases*	*Out-Breaks*	*Cases*	*Out-Breaks*	*Cases*	*Out-Breaks*	*Cases*	*Out-Breaks*	*Cases*
	1945	..	..	7	458	104	5,706	..	..	111	6,164
	1946	..	..	6	346	113	4,122	..	..	119	4,468
Staphylococci	1947	..	..	9	60	128	4,292	1	4	138	4,356
	1945–7	..	..	22	864	345	14,120	1	4	368	14,988
	1945	1	195	8	1,003	33	1,120	1	31	43	2,349
	1946	3	2,529	3	23	36	2,068	..	..	42	4,620
Other Known Groups	1947	..	..	3	76	42	1,208	4	343	49	1,627
	1945–7	4	2,724	14	1,102	111*	4,396	5	374	134	8,596
	1945	15	5,465	5	126	106	4,162	7	543	133	10,296
	1946	27	1,942	3	242	119	4,008	4	293	153	6,485
Undetermined	1947	18	5,577	5	54	121	5,811	18	1,029	162	12,471
	1945–7	60	13,684	13	422	346	13,981	29	1,865	448	29,252
Totals	1945–7	64	16,408	49	2,388	802	32,497	35	2,243	950	52,836

* Does not include 9 duplications of mixed contaminants listed in Table 6

NOTE: 1. Outbreaks and cases with mixed contaminants are listed individually in each group except where stated (*) above.
2. Outbreaks due to mushroom poisoning are not listed.
3. No estimates of cases were reported with two outbreaks of undetermined etiology.

TABLE 12

*Frequency of Involvement of Various Contaminated Vehicles in 392 Bacterial Enteric Outbreaks * Caused Unquestionably by a Single Organism*

		Meat Or Meat Products				Bakery Products				Potatoes			Egg		Fish									
Organism	*No. of Outbreaks*	*Ham*	*Other*	*Total*	*Poultry*	*Creamed* [a]	*Custard* [a]	*Other*	*Total*	*Salad*	*Other*	*Total*	*Noodle Macar. Spagh.*	*Other*	*Salad or Creamed*	*Other*	*Total*	*Vegetables*	*Water*	*Milk and Milk Products*	*Shellfish*	*Miscellaneous Vehicles*	*Unknown Vehicles*	*Total*
Staphylococci	304	50	58	108	67	68	24	15	107	21	5	26	9	14	3	7	10	6	0	20	1	3	7	378
Salmonella *	54	2	13	15	10	7	1	0	8	1	0	1	0	4	1	1	2	7	0	8	1	3	5	64
Shigella	13	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	9	13
Streptococci	11	0	2	2	4	1	0	1	2	2	0	2	0	0	0	0	0	0	0	1	0	0	0	11
E. coli	5	0	0	0	1	1	0	2	3	0	0	0	0	0	0	0	0	1	1	0	0	0	0	6
Miscellaneous †	5	0	1	1	1	0	0	0	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0	5
Total	392	52	75	127	83	77	25	18	120	25	5	30	9	18	4	8	12	14	4	31	2	7	21	477

* Includes 1 mixed outbreak involving 2 species of salmonella.

† *B. paracolon, Proteus vulgaris, Pseudomona aeruginosa, B. faecalis alcaligenes,* Gram-negative bacillus.

[a] Although basic ingredients are similar, this breakdown is made in order to conform to common usage.

ucts was almost equal between chicken and turkey.

Almost all (96 per cent) of the ham-borne outbreaks were staphylococcic. Outbreaks transmitted by the creamed custard bakery products were staphylococcic 90 per cent of the time. Contamination with staphylococci occurred in 86.5 per cent of all potato-borne outbreaks, and all 9 of the egg-flour combination of noodles, spaghetti, and macaroni were responsible for staphylococcic outbreaks only. For proper evaluation, however, it must be borne in mind that staphylococci were responsible for 77.5 per cent of the 392 outbreaks which are considered in Table 12.

Fifty-four of the 392 outbreaks (13.8 per cent) were due to salmonellae. The most common food groups acting as vehicles in these infections were:

1. Meat and meat products—27.8 per cent of the salmonella outbreaks
2. Poultry—18.5 per cent of the salmonella outbreaks
3. Bakery products—14.8 per cent of the salmonella outbreaks
4. Milk and milk products—14.8 per cent of the salmonella outbreaks
5. Vegetables—13.0 per cent of the salmonella outbreaks

No particular meat product plays a dominant role as a vehicle in salmonella infections as ham does in meat-borne staphylococcic disease. While poultry replaces bakery products as second in order of frequency, it does not carry a disproportionate share of salmonella infection (12.5 per cent of all poultry-borne outbreaks). Creamed-custard bakery products carry a normal share of salmonella outbreaks (9 per cent), while other bakery products rate extremely low in frequency of involvement, as does ham. It would seem that potatoes and the egg-flour products (noodles, macaroni, etc.) rarely carry salmonella infections. Although almost all the vegetable-borne outbreaks involved staphylococci and salmonellae in approximately equal numbers (6 and 7 respectively), yet for the salmonellae it would seem that vegetables play a more important role as vehicles (13 per cent of all salmonella outbreaks) than for staphylococci (2 per cent of all staphylococcal outbreaks). About 26 per cent of the milk-borne gastroenteric disease outbreaks considered in this table were due to salmonellae; 65 per cent to staphylococci.

In 9 of the 13 shigella caused outbreaks the vehicle of transmission could not be determined. In the other 4 outbreaks, water was the vehicle in 2 instances and milk in 1.

Of 11 gastroenteric disease outbreaks which were caused by streptococci, poultry was the vehicle in 4; meat prod-

TABLE 13

Fatality Rates

Organism	*No. of Outbreaks*	*No. of Cases*	*No. of Deaths*	*Age or Age Group*	*Fatality Case Ratio*
Staphylococci	11	251	11	Not stated-6, New-born-1, 13 Mos.-1, 4 yrs.-1, 51 yrs.-1, 70-1	4.4
Salmonella	4	142	4	Not stated-3, New-born infant-1	2.8
Shigella	2	22	2	Not stated-2	9.1
Pseud. aeruginosa	1	468	9*	Not stated-9	1.9
Unknown	9	262	15	Not stated-6, infants-7, child-1, 73 yrs.-1	5.7
	—	——	—		
Total	27	1,145	41		

ucts, bakery products and potatoes were involved twice each, and milk and milk products once.

Three of the 5 *E. coli* outbreaks were transmitted by bakery products.

FATALITY RATES

Forty-one deaths were reported in 27 outbreaks, with a total of 1,145 cases. Based on these outbreaks, the case-fatality rate was highest among the shigella caused diseases—9.1; second highest among those outbreaks of undetermined etiology—5.7; third in staphylococcal outbreaks—4.4; and 2.8 in salmonellae outbreaks. There were 9 deaths reported in a single large outbreak attributed to *Pseudomonas aeruginosa* with a rate of 1.9.

Of the 41 reported deaths, information concerning the age or age group was not given in 26. Of the remaining 15, 10 deaths were in infants 13 months of age or under, 2 in children under 5 years of age, and 3 in adults, one of whom was 51 years old and two over 70 years of age (Table 13).

DISCUSSION

Much space in this article has been devoted to the presentation of evidence showing the complete inadequacy of diagnostic terminology as commonly used today for bacterial gastrointestinal diseases. We have shown that such diagnoses as diarrhea, food poisoning, gastroenteritis, and dysentery, do not refer to clinical entities. Neither is such usage based upon any differential epidemiological pattern or any bacteriologic foundation. Even "dysentery" is no exception to this generalization—"Clinical dysentery may be caused by (1) *Shigella,* (2) *Salmonella,* (3) *Endamoeba histolytica,* (4) *Proteus morganii,* (5) paracolon bacilli, and (6) a virus."[3] And, "the term 'dysentery' is frequently used by the public—and at times by the medical profession—to refer to any severe diarrhea . . . the use is unfortunate as it tends to classify together too many disease conditions of very different etiology."[4] Both these quotations are from widely used recently revised standard reference sources.

In a previous article,[5] referring particularly to staphylococcal food poisoning, the author stressed the need for additional data. The information presented in this paper has been available for several years—all that was required was a study of such data based upon etiology. The major stimulus toward an understanding of the food-borne outbreaks of the various gastroenteritides was the discovery by Dack of staphylococcal enterotoxin, and the recognition of a definite epidemiologic pattern in the nature of the outbreaks which resulted from its ingestion. The full value of this clarification has never been completely utilized because of a failure to appreciate the relative incidence of staphylococcal outbreaks compared with those of other bacterial origin. We have yet to find a description of the incidence of staphylococcal food-borne outbreaks which did not, in essence, state that they were "*probably*" the most frequent of all bacterial food-borne outbreaks of gastrointestinal disease. We have shown in this paper that they are responsible for at least *three-fourths* of all such outbreaks—and are reported with 4 to 5 times the frequency of the next most common offenders—the salmonellae.

The term "food poisoning" should long since have been abandoned to the public by the medical profession, and "diarrhea" and "dysentery" recognized merely for what they are—descriptive indications of disease due to varying etiology. We should like to see the universal adoption of the term "gastroenteritis" modified by the use of the etiologic agent. Over the past few years, there has been a tendency to differentiate bacterial "food poisoning" into two types, the enterotoxic (at present staphylococcal only) and the infectious (salmonellae, streptococci, etc.). The substitution of "gastroenteritis" for "food poisoning" and the wider use of this classification would be a further step in the right direction. The terms "salmonellosis" and "shigellosis" are being interpreted by many as synonymous with acute salmonella gastroenteritis and shigella gastroenteritis (bacillary dysentery) respectively. In view of the protean nature of these infections, this adds more confusion to an already well confused subject. In many cases, food poisoning, salmonellosis, and shigellosis are listed as separate reportable diseases —a more recent trend toward unnecessary complication in view of overlapping. To avoid this, a redefinition of "food poisoning" is required and this has been accomplished by the A.P.H.A. which limits its use to bacterial intoxications due to staphylococci and *B. botulinus*.[6]

Preventive medicine, perhaps more than any of the other branches of medicine, depends essentially on the coöperation and integration of the medical sciences and specialties in all fields. The base for this pyramidal organization is the general practitioner. With the exception of outbreaks of gastrointestinal disease occurring in institutions, all others as well as endemic cases, come first, and usually only, to his attention. He must not dismiss these short-lived illnesses as "summer diarrhea," "food poisoning," or "intestinal flu or grippe." He is best equipped to supply us with the necessary clinical information which may enable us to differentiate variations in the clinical pictures of these disorders. Mailing tubes for fecal specimens should be an integral part of his equipment, and such specimens should be secured before the establishment of any therapeutic regime, particularly with the antibiotics.

This study of the general incidence of gastroenteric disease outbreaks speaks well for the effectiveness of sanitary measures in the control of water- and milk-borne diseases. However, the large number of cases which occasionally arise from water-spread disease outbreaks emphasizes the ever-present danger from a relaxation of such measures of control, as well as the need for an extension of such facilities. This need, particularly in respect to the private and semi-public supplies of institutions and resorts in rural areas, has been well demonstrated by the recent study of Eliassen and Cummings.[7] That the contaminating organism could not be isolated in 55 of the 57 water-borne outbreaks in this series focuses our attention upon the advisability of a reevaluation of present methods and techniques in such efforts.

Since foods, other than milk and its products, are demonstrated as the major vehicles responsible for 90 per cent of our present gastroenteritis problem, the need for concentration on this aspect of control becomes apparent. This problem ultimately resolves itself into a consideration of control measures against staphylococcal and salmonella gastroenteritis.

It is believed that, although in almost half the reported outbreaks the responsible bacterial agent was not determined, there would be no significant change in the relative etiologic distribution of such outbreaks if the agent had been identified. In many instances failure is due to the delayed reporting of these outbreaks by the physician, or to a complete lack of reporting, so that they come to the attention of the health authorities via newspapers or radio much too late for proper epidemiologic study. It is not believed, as has been too frequently stated in the literature, that the incidence of food-borne outbreaks is increasing. The apparent increase has been due to two factors— an increase in the number of states requiring reporting and improvement in diagnosis. This is well exemplified by

Felsen's[8] study of the apparent rise in incidence of bacillary dysentery in this country from approximately 1,000 reported cases in 1933 to 38,000 cases in 1944. He shows that this apparent rise in the incidence of bacillary dysentery is due largely to the diagnosis of previously unclassified diarrhea. We are tempted to employ our previous estimates of relative incidence, and state that on such a basis the probable number of cases of staphylococcal enterotoxin gastroenteritis in 1944 would be between 570,000 and 1,000,000! In any case the vast number of mild, subclinical, undiagnosed, and therefore unreported, cases would not be included.

Staphylococcal Enterotoxin Gastroenteritis

Almost 80 per cent of all reported bacterial outbreaks of gastroenteritis belong to this group. We must differentiate this type from the infectious forms, inasmuch as the enterotoxin is preformed in the contaminated food—although it must be understood that not all staphylococcal strains are capable of producing such enterotoxin. It is the physiologic action of the enterotoxin which accounts for the " explosiveness " of these outbreaks.

The median incubation period as shown in this study, and which conforms with all previous reports,[9–18] is about 4 hours, although some cases may have their onset immediately upon ingestion of the contaminated food. Almost 90 per cent of those partaking of the implicated food will have symptoms within 8 hours after ingestion. This point is of the utmost value in differentiating between the various epidemic forms of gastroenteritis, both clinically and epidemiologically. In this study, 95 per cent of all outbreaks of determined etiology, with incubation periods of 11 hours or less were of staphylococcal origin. Where outbreaks falling within the ranges mentioned seem to be due to other bacteria, due scepticism must prevail. Dack[9] has well covered the probable errors in this respect and states, " many bacteria other than staphylococci have been assigned as causative agents in . . . outbreaks that were undoubtedly caused by staphylococcus enterotoxin. Although it is possible that other agents may simulate staphylococcus food poisoning, there has never been a clearly proven example of such an exception." The only epidemiologic exception, and therefore a valuable differential point, might be those rare instances of outbreaks due to food-borne chemical poisons both organic and inorganic, or ingestion of the uncommon toxic varieties of plants and animals.

Further differentiation of this form of gastroenteritis from other bacterial forms awaits the interest and contribution of the clinician and practitioner. Descriptions characterized by " nausea, vomiting, and diarrhea " are completely inadequate for the differential diagnosis of even the more or less typical cases. To our knowledge, the first comprehensive presentation of symptomatology capable of evaluation was made as recently as the present year.[5]

The present study confirms accepted concepts concerning the importance of ham as a food item of transmission in these outbreaks. Other meats such as pork and tongue are apparently comparatively unimportant. Creamed and custard pastries are responsible for most of the outbreaks due to bakery products (86 per cent). The importance of poultry products has been somewhat underestimated. It would seem that public health emphasis on the preparation, handling, and refrigeration of these three items alone could cut the incidence of this illness in half.

Since we have shown that the incidence of this form of gastroenteritis is still relatively high in the colder months, such measures as are taken must not be restricted to the warmer months alone. Everyone handling food who has superficial skin, eye, ear, nose, and throat lesions harboring enterotoxin producing staphylococci is a potential source of contamination. Studies show that the incidence of staphylococci in the nose and throat of the general population is quite high, ranging from 76.3 to 86.1, and that staphylococcal food outbreaks are associated with a high enterotoxin producing staphylococcus carrier rate among incriminated food handlers.[17]

The prevailing concept that enterotoxin gastroenteritis, because of the rapidity of recovery among affected individuals, need not be taken seriously by the practitioner, is quite erroneous. While reported fatality rates vary widely,[16, 19] it would seem that the most important factor is the age and debility of the patient. As with other forms of acute gastroenteritis, the case fatality rate is high among infants and the aged. This has not been generally recognized for staphylococcal gastroenteritis, and while our own tabulation may be inadequate, it must certainly be considered highly suggestive and worthy of additional investigation. Until evidence is presented to the contrary, however, it would seem advisable for clinicians to keep patients of both extremes of age under careful observation during an attack.

Salmonella Gastroenteritis

The establishment of Salmonella Centers throughout the country, and the identification of approximately 170 species of these organisms, most of them pathogenic to both man and animals, though a fascinating study to the bacteriologist and epidemiologist, have given this form of gastroenteritis an importance in relation to staphylococcal intoxication which is not justified by its comparative incidence. We have shown on the basis of available evidence and on the assumption that most other factors are equal, that reported outbreaks of salmonella gastroenteritis are one-fourth to one-fifth as frequent as staphylococcal, even though they represent by far the second most common form. While these organisms may produce disease of almost any of the body tissues (and this is true of most pathogenic bacteria), the gastrointestinal tract is the most frequent and favorite site.

The incidence of the different salmonella species varies in different regions of this country, and in other countries as well. Nevertheless the predominating specie is *S. typhimurium*, followed by other members of the Kauffmann-White C group.[2, 14, 20, 21] In our series of reported salmonella outbreaks approximately 25 per cent were identified as due to *S. typhimurium*. This conforms closely to other reported isolations.[2, 20, 21]

The incubation period mean in this study is 18.2 hours for the outbreaks and 17.9 hours for the cases. The interquartile ranges vary between 10.2 hours and 27.5 hours. Since there is no recognized difference in the clinical pattern presented by all these gastroenteritides (all being described by varying degrees of nausea, vomiting, fever, diarrhea, abdominal pains and cramps, etc.), the difference in the incubation periods presented by these various forms becomes the most important differential feature. It is obvious that staphylococcic outbreaks are much more "explosive" in epidemiological pattern than those due to the salmonellas. In many instances the attending physician will be called to the site or "affair" at which the contaminated food had been eaten in staphylococcal gastroenteritis, while in most instances of the salmonella type other meals are likely to have intervened between the ingestion of the contaminated food and the onset of illness. The history will show that in many instances the patient is aware of others who had participated in some previous meal who were also ill. While various species of salmonellae may vary in their pathogenicity to man, we found no significant variation in either incubation periods or ranges of the more common species encountered in this study. *S. choleraesuis* which seems to be the most virulent of the group for man was only encountered once during these outbreaks. While *S. enteritidis* [14] and *S. choleraesuis* [3] are stated by some to occur next in frequency to *S. typhimurium*, in this study *S. newport*, *S. oranienburg* and *S. montevideo* were isolated next in the order of frequency mentioned. This is more in accordance with the recent work of Seligmann, et al.,[2] Edwards, et al.,[20] and Felsenfeld and Young [21] in this country.

The distribution of the salmonellae is universal, and their natural habitat seems to be the intestinal tract of man and animals. They have been found in horses, cattle, sheep, swine, fowl, rodents, and dogs and cats. They have been isolated from eggs and egg powders. Recent studies tend to show that 2–5 per cent of apparently healthy individuals are carriers of *Salmonella*,[2, 19] and that the human carrier is the most common vector of the infection in man. Household pets have been implicated in the serious choleraesuis infections in children, and rats and mice as sources in the contamination of foods. Frequent vehicles of transmission have been listed as water, meats, poultry, eggs including spray-dried (used for salad dressings and desserts), cake fillings and pastries.[3] This study shows that meat products, fowl, bakery products (especially creamed), milk and milk products, vegetables, and eggs are the most frequent vehicles in the order listed. Not in a single outbreak, however, was water listed as a vehicle of transmission. Edwards, *et al.*, believe that fowls constitute the greatest reservoir of the bacteria in this country, and that a high incidence of a given type in fowls in a certain locality is accompanied by a high incidence of the same type in man.[20] They emphasize, moreover, that "both normal human carriers and animal reservoirs of infection have their place in the epidemiology of salmonellosis, and each should be given due consideration."

Our study of the seasonal variation of these outbreaks shows a marked decrease in salmonella gastroenteritis during the colder months and a peak incidence during the summer. This seems to indicate that the human carrier is not as great a source of infection or contamination as in the case of staphylococcal gastroenteritis, and to point to the value of refrigeration as a means of control. The interesting study of Felsenfeld and Young,[21] demonstrates also the value of adequate meat and fowl inspection in reducing the danger of salmonella disease.

Previously published reports of fatality rates in salmonella disease vary from 1.4 to 5.1 per cent.[2] The rate in this series is 2.8. In view of the particular affinity of salmonellae for the younger age groups, one is inclined to expect higher fatality rates than those cited. This is true for infection with *S. choleraesuis* in which Seligmann, *et al.*, mentions a rate as high as 26 per cent.[2]

Shigella Gastroenteritis

Bacillary dysentery may be considered synonymous with *Shigella* gastroenteritis. While we are becoming aware to a greater extent of the increased prevalence of this disease as compared with previous estimates,[8] it must be recalled that such prevalence is far below that of the staphylococcal and salmonellae forms. The predominant role of *S. paradysenteriae* found in this study as the cause of this form of gastroenteritis, followed by that of *S. sonnei*, is corroborated by the work of Weil [22] in which these two strains constituted at least 90 per cent in all sections of the country studied.

The median incubation period for our series was 42 hours for the outbreaks and 53.4 hours for the cases. Neither the epidemiologic pattern nor the clinical onset in patients (prodromal period) should be confused with the staphylococcal or salmonella types of gastroenteritis—explosive, less explosive, and non-explosive should describe both these features in these three diseases respectively.

Unlike the salmonellae, man is the sole source of the shigella organisms. As many as 9 asymptomatic or convalescent carriers have been found for each current case of bacillary dysentery.[23] The carrier state may persist for years,[24] and where poor excreta disposal exists, flies may become important vectors in the transmission of the bacteria to food, and the long viability of the organisms in water (6 months), and inapparently soiled clothing for many days increases the problem of control.

In too many outbreaks in our series, the vehicle of transmission could not be determined. This is to be expected in view of the long incubation period. In those instances where the vehicle was determined, water, milk, and meat products were involved.

Shigellae disappear rapidly from stools, making it advisable to use Bang-xang and Eliot [25] citrate desoxycholate mixture in buffered physiological saline in the medium, and in the preservative particularly for shipment. Proper collection and selection of the specimen is extremely important in the isolation of these organisms. Serologic diagnosis may be of value—but it must be remembered that agglutinins are produced late in the disease and, inasmuch as normal individuals may show titers of 1:80 to 1:320, only a series showing rising titers at this stage of disease may be considered diagnostic.[26]

Streptococcal Gastroenteritis

Thirty-four outbreaks were studied in this presentation, of which 21 showed mixed contamination; 17 of these mixed outbreaks showed the presence of staphylococci. The incubation period medians of 6 hours for the 9 unmixed outbreaks and 10.3 hours for the cases are well within the ranges quoted by Dack [16] in his presentation of this form of gastroenteritis. The alpha streptococci, Lancefield Group D, (*S. fecalis*) are the types previously implicated as probable causes of gastroenteritis, particularly when found in overwhelming numbers in the contaminated foods. An equal number of outbreaks in this series were attributed to *S. viridans,* of the Lancefield N Group.

In evaluating the role of the streptococci in the production of acute gastroenteritis, we should like to quote Zinsser [3] to the effect that "hemolytic streptococci are preëminently secondary invaders superimposed on other bacterial . . . diseases" and add "superimposed on other bacteria-contaminated foods." Acute gastroenteritis should not be attributed to these organisms when mixed contamination with other pathogens is found, and until careful and exhaustive bacteriologic study has failed to reveal the presence of other more likely pathogens.

Poultry predominated as the vehicle of transmission, being involved twice as frequently as meat, bakery products, and potatoes.

No fatalities were reported in these outbreaks.

Gastroenteritis Due to Other Bacteria

In discussing the role played by other bacteria as factors in the production of acute gastroenteritis, the normal intestinal flora of man must briefly be reviewed. It must be recalled that the bacterial flora of the canal varies at different ages, with health and disease, and with diet. In spite of this, valid generalizations may be made. For example, *E. coli* constitutes 75 per cent of the intestinal bacteria of adults. In breast-fed infants, *A. aerogenes* and *E. coli* are normally found in the lower intestine, and enterococci in the upper small intestine. Anaerobes predominate in the cecum and rectum. Artificially fed infants show an increase in the predominance of the coli-aerogenes group.

During the three year period encompassed in our study, 10 outbreaks of *E. coli* gastroenteritis were reported. Half of these outbreaks showed contamination with other organisms. Of the 5 mixed outbreaks concerned, 4 of the other groups of organisms are recognized pathogens capable of causing gastroenteritis, and we are inclined to accept the presence of *E. coli* as secondary invaders in food specimens, and as normal intestinal constituents in fecal specimens. The incubation periods of the 5 unmixed outbreaks yielded medians of 9.5 hours for the outbreaks and 11.7 for the cases. Even where *E. coli* is found in food specimens with no other determined contaminant, in view of the fact that it is relatively unimportant as a disease producer, its presence in the food, as in water, should be regarded merely as an index of fecal contamination, and a more intensive search made for such enteric pathogens as salmonellae and shigellae.

Four outbreaks showed the presence of *A. aerogenes*. All 4 also yielded other organisms which may be recognized as the responsible pathogens. So far as is known, *A. aerogenes* is non-pathogenic to man, and widely distributed in nature. It constitutes part of man's normal intestinal flora. It is extremely abundant in sour milk and its products. The presence of *A. aerogenes* in feces or in food samples suspected as vehicles of disease transmission should never be regarded as an indication of its responsibility for the gastroenteritis.

Proteus vulgaris was involved in 4 outbreaks, 3 of which showed mixed contamination. However, *Proteus* is said to be a recognized pathogen and causes a shigella-like gastroenteritis. The rarity of such outbreaks does not warrant additional comment.

Viruses have too frequently been held responsible for outbreaks of gastrointestinal disease. In the great majority of instances this represents mere wishful thinking on the part of the medical profession which comes in closest contact with frequent outbreaks of gastroenteritis among the population. Since the majority of cases seem to recover rapidly, and since there are no apparent complications and sequelae, it may seem that laboratory study is not indicated, and therefore a diagnosis of convenience, such as intestinal grippe or flu, or virus diarrhea, is made. We feel that more careful investigation would show these outbreaks to be due to the more common bacterial groups discussed in this paper. Several outbreaks of acute gastroenteritis of epidemic proportions (Epidemic Diarrhea and Epidemic Diarrhea of the Newborn) seem to be spread through respiratory channels. While in these outbreaks recent investigation indicates the probability of a virus as the infecting agent, such viruses have not, to our knowledge, been isolated in a single instance.

CONCLUSIONS

1. A great deal of the confusion existing today in our understanding of the commoner forms of gastroenteritis is basically due to poor diagnostic terminology, in which unrelated syndromes seem synonymous, and related syndromes are often classified independently.
2. It has been suggested that the present trend toward etiologic diagnosis, employed to some extent by bacteriologists and health agencies, be utilized by the clinician, and that the laboratories be used to a greater extent as a diagnostic tool.
3. The need for additional clinical data in the differentiation of the various forms of acute gastroenteritis has been stressed.
4. The seasonal variation in the incidence of various forms of vehicle-borne gastrointestinal disease has been presented, as well as the seasonal variation in the major types of bacterial gastroenteritis.
5. An approximation of the relative incidence of the more common types of bacterial gastroenteritis has been offered.

6. The incubation periods for the more common forms of bacterial gastroenteritis have been calculated, and suggested as a means of epidemiological and clinical differentiation.
7. A study of the major food items involved in the transmission of these diseases is presented and evaluated.
8. Case fatality rates seem more dependent on the age groups affected than upon the infecting organism or toxin.

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Training in Atomic Defense

"Environmental Sanitation Aspects of Civilian Defense in an Atomic Disaster" was the subject of a recent three day conference in Albany, under the auspices of the Bureau of Environmental Sanitation, New York State Department of Health. The object of the meeting was to provide supervisory engineers, veterinarians, and sanitarians with information on which to plan for dealing with possible atomic disasters. Speakers were drawn from the U. S. Public Health Service and from the New York State Departments of Health, and of Agriculture and Markets. Representatives from state, county, and city health departments, from other state agencies, and from 14 other state health departments were present, totaling about 150 persons.