

Bacteriophage Types of *Salmonella typhi* in the United States from 1974 Through 1981

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From 1974 through 1981, 4,089 isolates of *Salmonella typhi* were phage typed at the Centers for Disease Control and nine regional laboratories in the United States. The most prevalent types were degraded Vi (27%), E1 (20.6%), A (9.8%), C1 (5.7%), untypable Vi (3.5%), W form (3.5%), D1 (3.4%), B3 (3.4%), and F1 (2.4%). There were less than 2% of each of the remaining types. The distribution of phage types for this time period was similar to that seen in the periods 1966-1969 and 1970-1973, except that phage type B3 was one of the 10 most prevalent types in 1974-1981 but was not seen in 1966-1973. Phage typing is presently the most valuable laboratory tool for differentiation of strains of *S. typhi* in epidemiological studies.

Bacteriophage typing (phage typing) is presently the most useful laboratory method for evaluating a possible epidemiological association among strains of *Salmonella typhi* (1, 2). The Centers for Disease Control and nine regional laboratories located in the health departments of California, Georgia, Hawaii, Illinois, Louisiana, Minnesota, New York City, Pennsylvania, and Texas have tabulated the phage types of 4,089 *S. typhi* isolates encountered in the United States from 1974 through 1981. These tabulations were done as a part of a report on the worldwide distribution of phage types that is periodically published by the International Federation of Enteric Phage Typing (4, 5).

Table 1 gives the most common phage types encountered during three time periods that were chosen by the International Federation of Enteric Phage Typing. Degraded Vi, E1, A, and C1 were the most common types for all three periods. The phage type called degraded Vi (Vi

refers to the Vi antigen which must be present for phage typing) became the most prevalent type in the period 1970-1973 and remained so in 1974-1981. However, this phage type is heterogeneous in lysis patterns and is composed of many different patterns that do not fit into a named phage type. Some of these patterns can easily be differentiated and include (i) degraded Vi approaching A (this is also called the Mexican strain because it caused epidemic typhoid in Mexico in 1972 and 1973; it is lysed by all but 3 of the 104 phages used); (ii) degraded Vi resembling the B group (these phage patterns are similar to, but do not exactly fit, types B1, B2, or B3); (iii) degraded Vi-D1-N (this is called D1-N because it is lysed by the D phages [phages D1 through D12] as well as by phage N); (iv) degrad-

TABLE 1. Most common phage types of *S. typhi* for the three time periods

Phage type	% Found during:		
	1966-1969	1970-1973	1974-1981
Degraded Vi ^a	18.4	26.5	27.0
E1	23.8	24.8	20.6
A	6.5	6.2	9.8
C1	12.5	8.6	5.1
Untypable Vi	4.3	5.1	3.5
W form	3.7	3.5	3.5
D1	4.5	1.7	3.4
B3	0	0	3.4
F1	4.6	2.7	2.4
B1	2.6	1.7	1.7
46	3.0	1.6	1.4

^a Includes all the different patterns of this type mentioned in the text.

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ed Vi, C5 negative, 50 negative (or weak) (this type is lysed by all phages except C5 and 50 and is sometimes called the Naples strain). The epidemiological value of phage type degraded Vi is greatest in an outbreak situation during which

all isolates are typed at the same time and their patterns can be compared under the same conditions. The percentages of untypable Vi strains (defined to be strains which have the Vi antigen but are not lysed by any of the typing phages)

TABLE 2. Distribution of phage types of *S. typhi* observed in the United States, 1966-1981

Phage type	% Found during:			Phage type	% Found during:		
	1966-1969 (628) ^a	1970-1973 (2,138)	1974-1981 (4,089)		1966-1969 (628) ^a	1970-1973 (2,138)	1974-1981 (4,089)
A	6.5	6.2	9.8	G5	ND	ND	—
B1	2.6	1.7	1.7	H	—	0.2	—
B2	— ^b	0.7	1.8	J1	—	0.7	0.6
B3	—	—	3.4	J2	—	0.1	—
C1	12.5	8.6	5.1	J3	—	—	0.02
C2	—	0.2	0.07	J4	—	—	—
C3	0.3	0.1	0.02	J5	—	—	—
C4	0.6	0.3	0.6	K1	—	1.7	0.9
C5	—	0.1	0.2	K2	—	—	0.02
C6	—	—	—	K3	—	0.05	0.3
C7	—	—	—	L1	—	0.05	—
C8	—	0.05	0.2	L2	—	—	—
C9	0.5	0.2	0.2	M1	1.0	1.5	1.5
C10	—	—	—	M2	—	—	0.02
C11	—	—	—	M3	—	—	—
D1	4.5	1.7	3.4	M4	—	—	—
D2	—	0.9	0.5	N	—	1.3	0.8
D4	—	0.3	0.3	O	—	0.2	0.9
D5	—	—	0.05	T	0.5	0.3	0.3
D6	0.5	0.2	0.2	25	0.2	0.1	0.02
D7	1.8	0.7	0.1	26	0.3	0.1	0.7
D8	0.5	0.4	0.02	27	0.2	0.1	0.2
D9	0.8	0.9	0.2	28	0.3	0.4	0.7
D10	—	0.1	0.07	29	—	0.2	—
D11	—	—	—	32	—	—	0.02
D12	ND ^c	ND	—	34	—	0.05	0.2
E1	23.8	24.8	20.6	35	0.6	0.8	1.5
E2	0.3	0.4	0.5	36	—	—	0.3
E3	0.2	0.1	0.07	37	—	0.1	0.07
E4	—	—	0.07	38	0.8	1.7	0.8
E5	—	—	—	39	—	—	—
E6	—	—	0.02	40	0.3	0.05	0.7
E7	—	0.1	0.02	41	—	—	0.02
E8	—	—	—	42	—	—	—
E9	0.6	0.1	0.70	43	—	0.1	0.1
E10	—	0.1	0.2	44	—	—	—
E11	ND	ND	—	45	—	—	0.02
F1	4.6	2.7	2.4	46	3.0	1.6	1.4
F2	—	0.3	0.3	47	—	—	—
F3	—	—	0.02	48	—	—	0.4
F4	0.5	0.2	0.3	49	—	—	0.02
F5	—	0.05	0.05	50	0.3	0.05	0.02
F6	—	0.2	—	51	ND	ND	0.02
F7	—	—	—	52	ND	ND	0.02
F8	—	0.2	—	53	ND	ND	—
G1	0.2	0.05	0.4	54	ND	ND	—
G2	—	—	—	55	ND	ND	—
G3	—	—	—	Degraded Vi	18.4	26.5	27.0
G4	ND	ND	—	Untypable Vi	4.3	5.1	3.5
				W form	3.7	3.5	3.5

^a Numbers in parentheses indicate the total numbers of isolates phage typed during the indicated time period.

^b —, None found.

^c ND, Not determined (these represent new types not available earlier).

and strains that contained no Vi antigen (called phage type W form) remained relatively constant for the three time periods (Table 1). Interestingly, phage type B3 was seen from 1974 through 1981 but not from 1966 through 1973.

Table 2 shows the distribution of all *S. typhi* phage types for the three time periods 1966–1969, 1970–1973, and 1974–1981. These tabulations included isolates that were from sporadic cases as well as those involved in outbreaks. The data for 1966–1973 were reported previously (3). Epidemiologists can use this table to estimate the relative frequency of the phage types in the United States. For example, if a typhoid fever patient and a carrier are both found to be infected with a strain of phage type E1, the identity of this phage type provides only slight additional strength to any epidemiological association already demonstrated between the case and the carrier. This is because phage type E1 comprises about 20% of all isolates typed in the United States. In contrast, the discovery of a carrier or patient harboring an *S. typhi* strain of phage type G1 would strongly suggest an epidemiological link with any other case of infection with an organism of this phage type since G1 is rare; only 0.4% (15 of 4,089 isolates) was phage

type G1 in the period 1974–1981.

The phage typing system for *S. typhi* is internationally standardized, and the phage types are usually stable with person-to-person transfer and in outbreaks. The United States reports 400 to 500 cases of typhoid each year, and most of these are phage typed. We believe that the data obtained in our study will be of value to epidemiologists throughout the United States.

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