

# Occurrence and Distribution of Types of *C. diphtheriae*

California, July 1, 1940–June 30, 1948

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THE classical description of *mitis* and *gravis* types of *Corynebacterium diphtheriae* presented by McLeod<sup>1</sup> and his coworkers (Anderson, Happhold, Thompson) in 1931 and subsequently of the *intermedius* type<sup>2</sup> in 1933, presented a challenge to all public health bacteriologists. The severity of the disease due to the *gravis* type in Great Britain and Germany (1932–40) created interest and concern in regard to the current distribution of types in any area.

In 1943, McLeod<sup>3</sup> reviewed the studies of type which had been made in the intervening 10 year period, and concluded that there were only three areas—Central Europe, Great Britain, and Australia—“in which the quality and amount of work done is sufficient to give a fairly clear idea of the actual type distribution.” For the United States, McLeod reported the amount of work done as very limited, and concluded that the studies reviewed “suggest that *gravis* diphtheria as it has occurred in Europe has not yet been observed in the U.S.A.” No additional reports of studies on the occurrence of types of *C. diphtheriae* in this country have been found in reports published since those included in McLeod’s review. The epidemics of diphtheria in Europe during and since the war have focused the attention of public health workers upon diphtheria and the several unsolved bacteriological, clinical

and epidemiological problems which it presents.

This investigation was initiated in 1938 and was designed to study the occurrence and distribution of types of *C. diphtheriae* in California. The importation of the *gravis* type from Europe was considered a possibility, and a knowledge of the types currently present in the state seemed desirable. During the first two years the number of specimens studied was small and many were not properly identified. During this time the techniques of typing were tested and improved. These preliminary studies showed that all three types were present in California and that the *gravis* and *intermedius* types were most frequently found in cultures from cases in the southern part of the state.

Beginning in 1940, cultures were solicited from all public health laboratories in the state, but the threat of war in 1941, and the advent of war in 1942, disrupted the arrangements which had been made for the transmission of specimens so that the number received in the first four years was less than had been anticipated. The laboratories of the State Department of Public Health serve the rural areas of the state where laboratory facilities are not present locally. Through the coöperation of the Division of Laboratories of the State Department of Public Health, most of the cultures received from such areas were made available. At all times the

TABLE 1  
Types of *C. diphtheriae* Isolated from Individuals in California  
July 1, 1940-June 30, 1948

Type of <i>C. Diphtheriae</i>	Individuals from Whom <i>C. diphtheriae</i> Was Isolated					
	Total		Cases		Carriers or Unknown Status	
	No.	%	No.	%	No.	%
Total of all types	2,068	100	1,231	100	837	100
Mitis	1,221	59	690	56	531	63
Gravis	696	34	435	35	261	31
Intermedius	151	7	106	9	45	6

TABLE 2  
Reported Cases of Diphtheria in California for Which Type Was Determined,  
Distributed by Areas, July 1, 1940 to June 30, 1948

Area	Total Cases Reported in Counties from Which Cultures Were Received <sup>5</sup>	Cases from Which Strains Were Typed	
		No.	%
Total	6,023	1,231	20
Northern Counties <sup>1</sup>	1,016	219	21
Central Coast Counties <sup>2</sup>	1,091	387	35
Central Valley Counties <sup>3</sup>	1,023	164	16
Southern Counties <sup>4</sup>	2,893	461	16

<sup>1</sup> Amador, Butte, Calaveras, Colusa, Humboldt, Lake, Lassen, Mendocino, Modoc, Napa, Nevada, Placer, Sacramento, Shasta, Siskiyou, Solano, Sonoma, Stanislaus, Sutter, Tehama, Tuolumne, Yolo, Yuba.

<sup>2</sup> Alameda, Contra Costa, Marin, Monterey, San Benito, San Francisco, San Mateo, Santa Clara, Santa Cruz.

<sup>3</sup> Fresno, Inyo, Kern, King, Madera, Merced, San Joaquin, Tulare.

<sup>4</sup> Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, Ventura.

<sup>5</sup> Cases not included for year in which no cultures received from any county in area.

number and source of specimens submitted were determined by the cooperation of the bacteriologists in public health laboratories and the proximity of some of these laboratories to the School of Public Health. At no time was any deliberate process of selection of samples introduced.

From July 1, 1940, to June 30, 1948 (Table 1), the type was determined for 2,068 cultures of *C. diphtheriae* isolated from 2,068 persons. Of these, 1,231 (60 per cent) were from persons reported as cases of diphtheria and 837 (40 per cent) from carriers or persons whose status was unknown. Of these 2,068 persons, 1,221 (59 per cent) were found to harbor *mitis* type, 696 (34 per cent) *gravis* type, and 151 (7 per cent) *intermedius* type. From the 1,231 persons reported as cases of diphtheria, *mitis* type strains were isolated from

690 (56 per cent), *gravis* from 435 (35 per cent), and *intermedius* from 106 (9 per cent). From the 837 carriers or persons whose status was unknown, *mitis* type strains were isolated from 531 (63 per cent), *gravis* from 261 (31 per cent), and *intermedius* from 45 (6 per cent). The percentage of the reported cases of diphtheria for which the type was determined is shown by areas in Table 2. In the 8 year period the type was determined for 20 per cent of reported cases. The proportion of cases for which the type was determined was greater in the Northern and the Central Coast areas (21 per cent and 35 per cent) than in the Southern or the Central Valley areas (16 per cent each). It is recognized that the populations of these four areas are not comparable, since approximately 50 per cent of the state's population was concentrated in

Southern California according to estimates for July 1, 1944. The results (Table 3) show that *mitis* type *C. diphtheriae* was the type isolated most frequently from cases, carriers, and persons of unknown status throughout the state; that the *gravis* type occurred more frequently in the Southern and Central Valley areas than in the Northern or Central Coast areas, and that the *intermedius* type was found most frequently in the Central Valley area.

The distribution of *gravis* diphtheria is of interest particularly as it occurred in three metropolitan areas (Table 4). A comparatively high proportion of the *gravis* type was observed in cultures from Los Angeles County during the 8 year period, as had been suggested by the preliminary studies. For the first 4 years, the type was determined for only 86 (7 per cent) of reported cases but 43 (50 per cent) of these 86 cases yielded *gravis* type *C. diphtheriae*. In

TABLE 3  
*Types of C. diphtheriae in California from Individuals<sup>5</sup> Distributed by Areas*

Area	Individuals <sup>5</sup> from Whom Strains Were Typed		Types of <i>C. diphtheriae</i>					
	No.	%	<i>Mitis</i>		<i>Gravis</i>		<i>Intermedius</i>	
			No.	%	No.	%	No.	%
Total	2,068	100	1,221	59	696	34	151	7
Northern Counties <sup>1</sup>	373	18	261	70	98	26	14	4
Central Coast Counties <sup>2</sup>	634	31	449	71	138	22	47	7
Central Valley Counties <sup>3</sup>	245	12	125	51	72	29	48	20
Southern Counties <sup>4</sup>	816	39	386	47	388	48	42	5

<sup>1</sup> Amador, Butte, Calaveros, Colusa, Humboldt, Lake, Lassen, Mendocino, Modoc, Napa, Nevada, Placer, Sacramento, Shasta, Siskiyou, Solano, Sonoma, Stanislaus, Sutter, Tehama, Tuolumne, Yolo, Yuba.

<sup>2</sup> Alameda, Contra Costa, Marin, Monterey, San Benito, San Francisco, San Mateo, Santa Clara, Santa Cruz.

<sup>3</sup> Fresno, Inyo, Kern, King, Madera, Merced, San Joaquin, Tulare.

<sup>4</sup> Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, Ventura.

<sup>5</sup> Cases, carriers, and persons of unknown status.

TABLE 4  
*Gravis Type C. diphtheriae, Isolated from Cases Reported to the California State Department of Public Health from Selected Metropolitan Areas July 1, 1940-June 30, 1948*

Location and Period	Number of Cases Reported	Cases for Which Type Was Determined		Gravis Type <i>C. diphtheriae</i> Isolated	
		No.	%	No.	% of Cases Typed
California					
1940-1948	6,023	1,231	20	435	35
1940-1944	2,719	289	10	81	28
1944-1948	3,304	942	28	354	38
Los Angeles County					
1940-1948	2,361	420	18	214	51
1940-1944	1,168	86	7	43	50
1944-1948	1,193	334	28	171	51
San Francisco County					
1940-1948	308	124	40	6	5.0
1940-1944	106	9	8	0	0
1944-1948	202	115	56	6	5.0
East Bay Counties					
1940-1948	511	188	36	58	31
1940-1944	230	28	12	4	14
1944-1948	281	160	57	54	34

the last 4 years the type was determined for 334 (28 per cent) of reported cases, and 171 (51 per cent) of these cases yielded the *gravis* type. It seems evident that during the 8 year period at least 50 per cent of reported cases in this area were *gravis* diphtheria.

In San Francisco, another metropolitan area, the type was determined for 124 (40 per cent) of the cases in the 8 year period, 9 (8 per cent) in the first 4 years, and 115 (56 per cent) in the last 4 years. No *gravis* type strains were found in the first 4 years (the sample was very small); and only 6 (5.0 per cent) cases yielded the *gravis* type in the last 4 years when the type was determined for 56 per cent of reported cases. It would be difficult to explain this discrepancy at any time but doubly so when the movement of people to and from the ports and between these areas of wartime industrial production was constant during the war years. This failure of *gravis* diphtheria to spread from Los Angeles to San Francisco might be considered a matter of distance and chance, but the occurrence of *gravis* diphtheria in 58 (31 per cent) of 188 cases reported in Alameda and Contra Costa counties, across San Francisco Bay, certainly cannot be explained as due to distance or chance. From 1940 to 1948 there were 511 cases of diphtheria reported in these East Bay counties for which the type was determined in 188 (36 per cent), while at the same time 308 cases were reported in San Francisco City and County for which the type was determined in 124 (40 per cent) cases. In the first 4 years (1940-1944) the type was determined for only 28 cases in the East Bay, but no *gravis* type strains were isolated from cases until 1942-1944. In the last 4 years the type was determined for 160 cases of which 54 (34 per cent) were *gravis*. No explanation of this failure of the *gravis* type to spread from Los Angeles County or the nearby East

Bay counties to San Francisco can be offered.

The high proportion (Table 3) of *gravis* type *C. diphtheriae* in the persons residing in the northern counties is of considerable interest. In the first year of the study, cultures from 22 persons living in a small village in Calaveras County yielded *gravis* type strains of *C. diphtheriae* (12 reported cases). No *gravis* type strains were isolated from cultures received from this county in the subsequent 7 years. *Gravis* type strains were isolated from 25 cases and carriers in Butte County (another northern county) 1942-1948. In two small adjoining northern counties, Sutter and Yuba, strains of *gravis* type *C. diphtheriae* were isolated from cultures from 21 reported cases in an Agricultural Workers Camp during a 2 year period (1946-1948). The remaining cases from which *gravis* type strains were isolated were distributed in various counties in this northern area in the 8 year period.

Ninety (60 per cent) of the 151 *intermedius* type strains were isolated from cultures from persons in the Southern and Central Valley areas (Table 3). Of the 47 persons in the Central Coast area from whom *intermedius* type strains were isolated, 37 were found in a 2 year period (1944-1946). Thirty-two of these occurred in three counties—16 in one, and 8 in each of the other two counties. Twenty-nine of these 32 persons were reported as cases of diphtheria. The remaining *intermedius* type strains were isolated from cases or carriers in other areas and years.

#### SUMMARY AND CONCLUSIONS

*Mitis* type *C. diphtheriae* was the type most frequently found in cultures from cases, carriers, and persons of unknown status in all areas from which cultures were received. *Gravis* type *C. diphtheriae* was isolated from 35 per cent of the

reported cases from which strains were isolated. The percentage of isolations of the *gravis* type varied from 48 per cent in the Southern area to 22 per cent in the Coast Central area. In Los Angeles County, 51 per cent of the reported cases yielded *gravis* type *C. diphtheriae*. No explanation can be offered for the occurrence of *gravis* diphtheria in 31 per cent of the cases in the East Bay counties when only 5.0 per cent of cases in San Francisco County yielded *gravis* type strains. The *intermedius* type was found in the Southern and Central Valley areas throughout the period. Small outbreaks of diphtheria due to the *intermedius*

type occurred in 1944-1946 in three counties in the Central Coast area.

#### REFERENCES

1. Anderson, J. S., Happhold, F. C., McLeod, J. W., and Thompson, J. G. On the Existence of Two Forms of Diphtheria Bacillus—*B. diphtheriae gravis* and *B. diphtheriae mitis*—and a New Medium for Their Differentiation and for the Bacteriological Diagnosis of Diphtheria. *J. Path. & Bact.* 34:667-681, 1931.
2. Anderson, J. S., Cooper, K. E., Happhold, F. C., and McLeod, J. W. Incidence and Correlation with Clinical Severity of Mitis, Gravis and Intermediate Types of Diphtheria Bacillus in a Series of 500 Cases at Leeds. *J. Path. & Bact.* 36:169-182, 1933.
3. McLeod, J. W. The Types Mitis, Intermedius and Gravis of *Corynebacterium diphtheriae*. *Bact. Rev.* 7:1-41, 1943.

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## Senate Passes Health Units Act

Without a dissenting vote, the U. S. Senate on August 27 passed the local health units bill, S 522. This provides for federal grants-in-aid for the development of local health departments. The formula for federal reimbursement is based on population and need. In order to prevent piecemeal development, there must be a plan for complete coverage of the state acceptable to the Surgeon General of the U. S. Public Health Service, who also has authority to set standards of personnel, minimum population to be served by a department, activities to be carried on, etc.

Under the act, services for which federal funds may be used "may include services dealing with the diagnosis and prevention of disease, the control of communicable disease, health education, demonstrations, sanitation, vital statistics, the training of personnel for state and local public health work, and other aspects of preventive medicine; but shall not include medical, dental, or nursing care, except in the diagnosis or prevention of disease or the control of communicable disease, or the promotion, establishment, or maintenance of industrial accident prevention programs."