

# Geographical Distribution of Tetanus in the World, 1951-60

## A Review of the Problem

B. BYTCHENKO<sup>1</sup>

*The introduction of tetanus toxoid about three decades ago, which was followed in many parts of the world by programmes of immunization of the population, has contributed greatly to the control of tetanus in the developed countries. Nevertheless, during the decade 1951-60, tetanus remained an unsolved problem in many of the developing countries.*

*In the present report, it is shown, on the basis of the available literature and WHO statistics, that tetanus causes more than 50 000 deaths each year all over the world. Indeed, this figure should be regarded as an underestimate, since it only partially reflects the actual situation in the developing countries. The paper draws attention to the geographical distribution of tetanus in the world and indicates that existing "foci" or "zones" of infection may be attributed to environmental conditions as well as to social, economic and cultural factors.*

Although tetanus is a disease of high mortality, especially in regions of warm or temperate climate, it usually attracts little attention from the public health authorities, rarely being listed among the first ten causes of mortality. Such a situation creates the impression that tetanus need not be considered very seriously, perhaps because it is usually not transmitted from man to man, as are many of the major communicable diseases. This peculiarity, together with "the quietness of tetanus epidemics" (Tateno, Suzuki & Kitamoto, 1961), tends to conceal its hazards to the population. Each case of the disease appears to occur separately and unexpectedly, with no trace of contact with other cases. In this respect, cases of tetanus resemble cases of snakebite, except that persons bitten by snakes normally realize their danger immediately.

Despite intensive pharmacological and therapeutic research, the prognosis for each case of tetanus is doubtful; at present, the tetanus case-fatality rate is rather high (30% to 80%), indicating that at least three of every ten, at most four of every five, persons attacked by this disease will succumb to it. It has been said that tetanus is dangerous, not because it is large in number, but because it is rare (Schlesin-

ger, 1960). However, the "rarity" of this disease cannot be affirmed positively, since compulsory registration of tetanus morbidity has not been established in many countries of Africa, Asia, and South America. Consequently, data on tetanus from these areas are very incomplete and available only by extrapolation from reports on causes of death (in particular the epidemiological and vital statistics made available to WHO for the years 1950 to 1964).

Studies on the epidemiology and area distribution of tetanus have been reported fairly recently in Europe (Conybeare & Logan, 1951; Cimmino, 1951; Möze, 1955; Eckmann & Bisaz, 1956; Weller, 1956; Matveev, 1960; Kubinyi, Rudnai & Barsy, 1962-63); in North America (Axnick & Alexander, 1957); and in Japan (Tateno, Suzuki & Kitamoto, 1961). Attention to the importance of tetanus throughout the world was drawn by Matveev & Sergeeva (1959). According to the very approximate calculation of these authors, there were, during the nine years 1945-53 in the countries in which the incidence of tetanus was recorded, more than 350 000 cases, of which 115 000, or nearly one in three, terminated fatally.

This infection is characterized by the relative stability of its annual rates of morbidity and mortality

<sup>1</sup> Bacterial Diseases, Division of Communicable Diseases, World Health Organization, Geneva, Switzerland.

in most areas unless there has been interference in the form of campaigns of mass vaccination.

The purpose of the present paper is to draw attention to the importance of tetanus and the geographical distribution of this disease during the decade 1951-60. For this purpose, all available data were collected from various WHO documents and from a number of other publications that are included in the table of references at the end of this communication. It must be understood that, while the information gathered and presented here may be considered more or less reliable for European countries, the USA, Canada, Japan, Australia and New Zealand, it is very incomplete as regards Africa, Asia, South America and the countries of the WHO Western Pacific Region. It is to be hoped that further studies of the epidemiology of tetanus in various parts of the world will bring to light new facts that will help to describe the actual situation more precisely in the future.

#### AFRICA

It is known that tetanus is not rare in Africa (Bryant & Fairman, 1940; Lebon, Choussat & Chaussat-Clausse, 1949; Floch, 1949; Sarrouy et al., 1950; Behey, 1950; Armengaud, Frament & Biram, 1960; Smythe & Bull, 1961) and, although exact morbidity and mortality data are not available in many areas, those that have been made available to WHO for the years 1955-64 demonstrate that tetanus constitutes an important problem throughout that continent.

In the decade 1951-60, from 23 to 39 African countries, inhabited by between 105 and 139 millions of persons, recorded deaths from tetanus. Since the population of that continent in 1960 was reported to be 242 millions, it is evident that only about one half of the African population was covered by official records. Furthermore, even the official records must be considered to be incomplete, since they reflect only the situation in the towns and the larger hospitals, whereas tetanus occurs primarily in rural areas, in most of which tetanus is not a notifiable disease (World Health Organization, 1963).

The data collected by WHO, if summarized, indicate that mortality from tetanus appears to be increasing, the absolute number of cases ranging from 2124 in 1951 to 3180 in 1960. However, this trend can be explained as being due, primarily, to improvement in the registration of deaths. The same figures show that the geographical distribution

of tetanus in Africa was not uniform (see also Fig. 6, below). During the decade (1951-60) under discussion, there were real foci of infection in the Cape Verde Islands (mortality rate of 135 per 100 000 inhabitants) and some other places (Spanish Equatorial Africa, 13; Angola, 4.4, etc.). On the other hand, according to Bernard, Gallay & Laverdant (1963), tetanus was not so frequent in Algeria, where the tetanus mortality was only 0.45.

On the average, the mortality rate for the 39 African nations that supplied data on tetanus to WHO between 1951 and 1960 was approximately 2.0 per 100 000 population. Assuming that this figure could be applied to the entire population of the African continent (that is, approximately 235 000 000<sup>1</sup>), this would mean that more than 50 000 persons died from tetanus during that decade. However, this figure is probably far too low, since some reports on tetanus morbidity indicate that the situation was even more grave.

Johnstone (1958), for example, calculated that the morbidity rate for tetanus in the area around Ibadan, Nigeria, was about 26.6 per 100 000 inhabitants. In Somalia,<sup>2</sup> the number of cases of tetanus reported to the Ministry of Health in 1961 was 1230 (843 males and 387 females), which means that the morbidity rate was roughly 49 per 100 000 inhabitants.

Armengaud, Louvain & Diop-Mar (1962) have reported that, in one of the hospitals of Dakar, Senegal, 13% of all deaths from infectious diseases were attributable to tetanus, which killed more people than typhoid, pertussis, meningitis, diphtheria, or even malaria. In Nyeri, Kenya, Portsmouth (1963) reported having treated 245 tetanus patients between 1959 and 1961. Tetanus was the third most important cause of death in that area, being exceeded only by bronchopneumonia and gastroenteritis.

Generally speaking, the mortality from tetanus is rather high. For example, Tompkins (1959) has reported from Nigeria that, among 79 children aged from 1 to 7 years with tetanus, there were 25 deaths (31.6%). Behey (1950), in the Congo (Leopoldville) observed 87 patients with tetanus, 51 of whom (58.7%) died. Among 444 tetanus patients admitted to a hospital in Dakar, Senegal, during two years, 110 (25%) died (Armengaud et al., 1963). The low average lethality of the disease in

<sup>1</sup> Mean figure for 10-year period.

<sup>2</sup> Somalia, Ministry of Health (1963) *Five year plan for the development of Public Health Services* (unpublished).

this group of patients may be explained by the fact that no cases of tetanus neonatorum were included. In the age-group 5-10 years, lethality was only 13%, while for patients aged more than 40 years it was 60%. In one Congolese hospital alone, Perin & Van de Voorde (1963) treated 441 tetanus patients, of whom 195 (44.2%) died.

The tetanus case-fatality rate found in the Upper Volta by Pirame (1963) was 74.4%; that is, of 211 patients, 157 died. According to Baker (1963), among 430 cases of tetanus admitted to hospital in Kenya in 1959, about 211 deaths were reported, for a fatality rate of about 49%. Somewhat later, Baker & Grounds (1964) conducted a clinical trial of the treatment of 77 tetanus patients, with and without the use of anti-tetanus serum (ATS). These investigators found that, while 40% of the patients who received ATS died, 77% of the patients died who did not receive it. Portsmouth (1963), in Kenya, lost 102 (42%) of 245 tetanus patients treated by him; however, the lethality among patients in this group who were over 45 years of age was as high as 75%.

The reports of several authors indicate that, in Africa, the principal characteristics of tetanus are the same as in other parts of the world; that is, the disease usually attacks children under 15 years of age and adults in rural areas. Small-scale studies conducted in some places revealed that except between the ages of 20 and 40 years, during which period the incidence of tetanus is higher in women than in men, there is no appreciable difference in incidence between the sexes.

Most cases of tetanus occur after superficial wounds and injuries to the legs, arms, head or trunk, as well as after conditions such as chronic ulceration, otitis, dracunculosis and molluscum contagiosum. In a great number of reported cases, the site of infection could not be traced (Bryant & Fairman, 1940; Thiodet et al., 1956a; Fournier & Cabanel, 1957; Johnstone, 1958; Sénécal, 1958; Armengaud, 1959; Tompkins, 1959; Armengaud et al., 1963; Baker, 1963; Pirame, 1963; Pirame & Becquet, 1963; Perin & Van de Voorde, 1963; Portsmouth, 1963; Baker & Grounds, 1964). Some local customs, such as piercing of the ears, circumcision, or the stoppage of ear discharges with powdered earth, favour the conditions for contracting tetanus (Sénécal, 1958; Armengaud, Louvain & Diop-Mar, 1962).

Because its relative frequency is great and its case-fatality rate is very high, tetanus neonatorum

deserves special attention (Wright, 1960; Wright et al., 1961; Keet & Murray, 1962; Smythe, 1963). The Lambotte-Legrands (1950) reported that, in the Congo, a quarter of all neonatal deaths were attributable to tetanus. Among 441 patients treated by Perin & Van de Voorde (1963) in the Congo (Leopoldville), there were 261 children under one month of age (59.2%). In Dakar, Senegal, approximately 1% of the newborn in 1953 developed tetanus (Sénécal & Senghor, 1962). As stated by Gandy (1950), the number of cases of tetanus neonatorum in Morocco is as high as 5000 yearly. Slome (1954) has reported that, among 1019 deaths from tetanus that were reported in South Africa between 1944 and 1950, 60.9% were of children under one year of age, and at least 585 were of newborn children. When studying the causes of death on the Ivory Coast, Guinea, Senegal and Niger, Cantrelle, Etifier & Masse (1960) observed, in some areas, as many as 320 neonatal deaths per 1000 live-births, and tetanus was found to be the fourth most common cause of death.

The case-fatality rates for tetanus neonatorum in Africa, as described by several authorities, are summarized in Table 1. These data appear to be comparable with those obtained in other parts of the world. Wilkinson (1961), for example, has calculated, from the reports of several authors, that the average case-fatality rate for tetanus neonatorum is about 77.9%.

The high incidence of tetanus neonatorum in many parts of Africa is largely due to primitive obstetrical practices performed by unskilled medicine men or peasant midwives. Jelliffe (1958) has given the following typical details:

“In some regions the cord may be cut with a dirty knife, an unboiled bamboo chip, a spear or a piece of broken glass. Various dressings may be used including different types of vegetable oil, mud, local medicines and animal dung.”

Wilkinson (1961) writes that, in some tribes of Sierra Leone, the dirty juice of young banana shoots is applied to the umbilical cord.

Some workers have recorded a number of cases of tetanus that occurred after surgical operations or medical procedures such as injections and vaccinations (Sénécal, 1958; Pirame, 1963). In a study conducted at Dakar, Senegal, by Armengaud et al. (1963), among 444 cases of tetanus observed there were 34 (7.9%) that had resulted from infection after vaccination against tuberculosis (BCG) or,

TABLE 1  
CASE FATALITY OF TETANUS NEONATORUM IN AFRICA,  
AS REPORTED BY SEVERAL INVESTIGATORS

Country	Author	No. of cases	Case fatality	
			No. of deaths	% <sup>a</sup>
Nigeria	Jelliffe (1950)	25	24	(96)
South Africa	Klenerman & Scragg (1955)	4	1	(25)
Algeria	Sarrouy et al. (1956)	20	4	(80)
Algeria	Thiodet et al. (1956b)	4	3	(75)
Algeria	Fournier & Cabanel (1957)	20	18	(90)
Nigeria	Tompkins (1958)	141	126	89.3
Nigeria	Tompkins (1959)	29	24	(82.8)
South Africa	Wright (1960)	217	179	82.5
Uganda	Musoke (1961)	13	10	(76.9)
Sierra Leone	Wilkinson (1961)	114	83	72.8
South Africa	Wright et al. (1961)	68	34	(50)
South Africa	Keet & Murray (1962)	12	5	(41.7)
Senegal	Sénécal & Senghor (1962)	120	102	85
Upper Volta	Pirame (1963)	56	49	(87.5)
South Africa	Smythe (1963)	25	5	(20)
Congo (Leopoldville)	Perin & Van de Voorde (1963)	342	171	50
Total		1 210	838	60.9

<sup>a</sup> The figures in parentheses are percentages of numbers less than 100.

more commonly, against smallpox. In spite of treatment, eight of these patients died (fatality rate of 23.5%). It is of interest to note that a mass vaccination campaign against smallpox had been instituted in Dakar in July 1961, immediately after an outbreak of smallpox in that city in which 15 persons had fallen ill but none had died.

The seasonal distribution of tetanus in Africa cannot be established definitely, since the available data are inadequate. However, Sénécal (1958), Tompkins (1958, 1959) and Baker (1963) consider that the incidence of this disease is higher during the dry season than during the wet season. Wilkinson (1961), on the contrary, found that most patients with tetanus were admitted to hospital during the wet season. According to Armengaud et al. (1963), tetanus is observed as an endemic between December and April. These authors could give no explanation for this phenomenon.

Up to the present, the epidemiology of tetanus in Africa has not been investigated. Also, despite the alarming morbidity and mortality from this disease in some areas, the control of tetanus has not yet been properly organized. As shown in the *Second Report on the World Health Situation, 1957-1960* (World Health Organization, 1963), vaccination with tetanus toxoid is practised in some places, but not widely enough to protect even the population at greatest risk. In the overwhelming majority of African countries, active immunization with tetanus toxoid is not compulsory.

The obvious approach to the problem seems to be the organization of routine vaccination of the entire population, beginning with children and pregnant women. Immunization of all visitors to hospitals in areas where tetanus morbidity is very high can protect many people against this infection (Vervoorn, 1962). All vaccination campaigns should be ac-

accompanied by large-scale work on health education (Onuigbo, 1963).

#### THE AMERICAS

When considering tetanus in the Americas, one should bear in mind the entirely different climatic, geographical, natural and socio-economic conditions that exist, for example, in equatorial and polar regions. We shall therefore consider separately tetanus, first in Canada and the USA, then in Middle America, and finally in South America.

The border that separates the USA and Mexico also divides the Americas as far as mortality from tetanus is concerned. Northward of this line, mortality from tetanus is relatively low (0.17 per 100 000 population); south of it, during the decade 1951-60, the tetanus mortality per 100 000 ranged from 2.6 in Guatemala to 63.3 in the Dominican Republic, being on the average 8.50, or nearly 50 times as high as in the northern area.

#### *Canada and the USA*

The mortality rates for tetanus in four American countries that regularly submitted reports before 1950 are shown in Table 2, which demonstrates that in Canada and the USA there has been a consistent decline in the incidence of this disease, whereas no such change can be observed in the two Caribbean countries.

In Canada, the average number of deaths from tetanus per year has decreased from 48.0 in the period 1921-30 to 9.0 for the period 1951-60. In the USA, the tetanus death-rate, which averaged 330 per year in the period 1921-30, had declined to 203 annually in the period 1951-60.

While tetanus receives but occasional mention in the Canadian scientific literature (Silverthorne,

1947; Lessard, Potvin & Morin, 1960), this disease is still the subject of study and control in the USA. Axnick & Alexander (1957) have shown that the morbidity from tetanus per 100 000 population is highest in the states that have warm climates, such as Florida (1.5), Alabama (1.3), Georgia (1.0), Mississippi (0.9), Louisiana (0.9) and Arkansas (0.9). According to Long & Sartwell (1947), the mortality among the Negro populations of these states was more than three times the mortality among the whites. The geographical distribution of tetanus by age-groups in the USA during 1962 is shown in Fig. 1, while the data on morbidity, mortality and case fatality for that country are shown in Table 3. From these figures, it can be concluded that the average case-fatality rate from tetanus in the USA was as high as 62.26%, and that, unlike the morbidity rate, this fatality index did not tend to decrease. Heath, Zusman & Sherman (1964) have stated that, of three tetanus patients in the USA, two usually die. Previously, Calvin (1930) had noted that, among 183 cases of tetanus observed during a four-year period in Cook County Hospital, in Chicago, the case-fatality rate ranged, from year to year, from 27% to 82%.

Information gathered from several hospitals by Huntington, Thompson & Gordon (1937) showed that, of 72 patients who were not given anti-tetanus serum (ATS), 47 (65%) died, whereas among 228 patients who were given ATS intramuscularly and intravenously, the number of deaths was 142 (62%). In a series of case-histories that was analysed by Spaeth (1941), there were 462 deaths (82%) among 570 tetanus patients who were treated without ATS, as compared to 1088 deaths (56.7%) among the 1917 patients who had received ATS. Takos (1958) found that, of 170 tetanus patients treated in Miami,

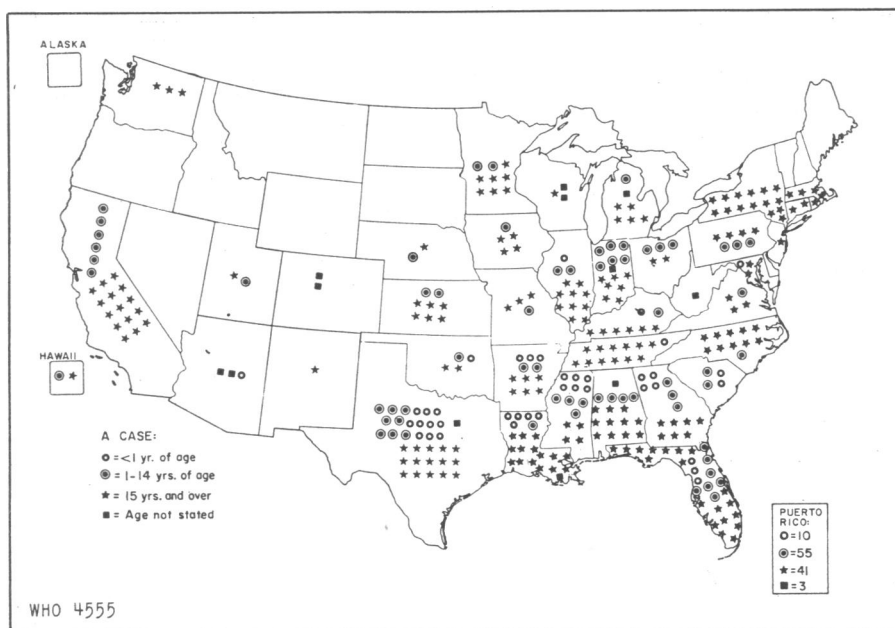
TABLE 2  
DECENNIAL MORTALITY RATES FROM TETANUS PER 100 000 INHABITANTS  
OF NORTH AMERICA AND CERTAIN CARIBBEAN COUNTRIES <sup>a</sup>

Country	1921-1930	1931-1940	1941-1950	1951-1960
Canada	0.49	0.31	0.125	0.06
Jamaica	no data	3.29	3.44	3.57
Trinidad and Tobago	no data	6.90	7.35	5.57
United States of America	0.20	0.76	0.38	0.18

<sup>a</sup> Annual Epidemiological and Vital Statistics, 1950-1964.

FIG. 1

DISTRIBUTION OF REPORTED CASES OF TETANUS IN THE UNITED STATES OF AMERICA,  
BY STATES AND BY BROAD AGE-GROUPS, IN 1962<sup>a</sup>



<sup>a</sup> From US Department of Health, Education, and Welfare, Communicable Disease Center (1963) *Morbidity and mortality weekly report*, 11, No. 53, p. 3.

TABLE 3  
MORBIDITY, MORTALITY, AND CASE FATALITY FROM TETANUS IN THE UNITED STATES OF AMERICA  
(1953-1961)<sup>a, b</sup>

Year	1953	1954	1955	1956	1957	1958	1959	1960	1961	Total
No. of reported cases	506	524	462	468	447	445	445	368	379	4044
Morbidity rate (per 100 000)	0.315	0.321	0.278	0.277	0.260	0.254	0.250	0.203	0.206	0.261
No. of deaths	337	332	265	246	279	303	283	231	242	2518
Mortality rate (per 100 000)	0.210	0.203	0.159	0.145	0.162	0.173	0.159	0.127	0.131	0.162
Case fatality (per 100 cases)	66.60	63.35	57.35	52.56	62.41	68.08	63.59	62.77	63.85	62.26
Population (in millions)	160.2	163.0	165.9	168.8	171.9	174.7	177.8	180.6	183.6	1546.90 <sup>b</sup>

<sup>a</sup> These figures include Alaska from 1959 and Hawaii from 1960.

<sup>b</sup> Data from: US Department of Health, Education, and Welfare, Communicable Disease Center (1963) *Morbidity and mortality weekly report*, 11, No. 53, p. 3.

TABLE 4  
CASE FATALITY FROM TETANUS IN CANADA  
AND THE UNITED STATES, ACCORDING  
TO VARIOUS AUTHORS

Author	No. of cases	Deaths	
		No.	% <sup>a</sup>
Gessner & Adiger (1916)	368	258	70.1
Ashhurst (1926)	23	8	(34.7)
Wainwright (1926)	540	305	56.5
Calvin & Goldberg (1930)	183	97	53.0
Graves (1930)	217	113	52.0
Boyce & McFetridge (1935)	185	110	59.4
Huntington, Thompson & Gordon (1937)	642	404	62.9
Moore & Singleton (1939)	102	51	50.0
Spaeth (1941)	2 487	1 550	62.3
Vener & Bower (1941)	100	29	29.0
Vinnard (1945)	352	159	45.1
Silverthorne (1947)	70	47	(67.1)
Noel (1950)	105	49	46.6
Takos (1958)	170	91	53.5
Perfstein, Stein & Elam (1960)	300	210	70.0
Greenfield (1963)	36	9	(25.0)

<sup>a</sup> The figures in parentheses are percentages of numbers less than 100.

Florida, 91 (53.5) died. These findings and those of some other investigators are summarized in Table 4. Not shown in this table is the interesting fact that, among tetanus patients, males prevail over females in a ratio of 2 : 1. According to Heath, Zusman & Sherman (1964), this disproportion was even higher in the non-white population, namely 6 : 1.

Most of the reported cases in the USA occurred after minor injuries, operations, abortions, child-birth, frostbite, burns, etc., but in a large number of cases, the site of the infection was not known (Calvin, 1930; Kirtley, 1940; Vinnard, 1945; Silverthorne, 1947; Turner & Galloway, 1949; Spivey et al., 1953; Adams & Morton, 1955; Creech, Glover & Ochsner, 1957; Takos, 1958; Perlstein, Stein & Elam, 1960; Botticelli & Waisbren, 1961).

During the period 1906 to 1927, 5767 deaths from tetanus neonatorum were recorded in the USA (Hines, 1930), the incidence of these deaths being highest in North Carolina, Louisiana and Pennsylvania. A study by Vinnard (1945) revealed that,

from a total of 352 cases of tetanus, there were 11 (3.1%) of tetanus neonatorum, with six deaths. In a review (1957), Axnick & Alexander showed that there was a relative increase of tetanus neonatorum from 1951 to 1954. The incidence in the age-group 0-1 years exceeded sevenfold to elevenfold the number of cases of tetanus in the ages above one year in the white population and by fourteenfold to seventeenfold the incidence in the non-white population. Of 170 tetanus cases treated by Takos (1958), 22 were neonatal, and of these, 21 terminated fatally. Heath, Zusman & Sherman (1964) have calculated that tetanus has been responsible for one quarter of the deaths of children before the twenty-eighth day of life.

The relatively high number of post-surgical cases of tetanus that has been found (Bunch & Quattlebaum, 1943; Vinnard, 1945; Takos, 1958) indicates the necessity for the improvement of preventive measures against infection in all patients who undergo surgery.

A marked variation in the seasonal distribution of tetanus in the USA has been noted. The incidence of this disease is highest in July, August, and September, and lowest during the winter months (Vinnard, 1945; Silverthorne, 1947; Noel, 1950; Heath, Zusman & Sherman, 1964; Top, Huggen & McCulloch, 1964).

The apparent decline in the morbidity and mortality of tetanus in the USA may be explained as being due to urbanization, industrialization, the mechanization of agriculture and, in particular, as the result of immunization of the population at risk. At present, the largest group of the population of the USA that has been protected against tetanus includes the veterans of the Second World War and young people who have been immunized in childhood. A programme of active immunization of as many persons as possible is being carried out by the American Medical Association, the American College of Surgeons, the American Public Health Association, the US Public Health Service and the American Academy of Pediatrics. For active-passive prophylaxis in the event of injury, adsorbed tetanus toxoid, liquid tetanus toxoid and anti-tetanus human globulin are available commercially everywhere in the USA (Skudder & McCarrol, 1964). The *Second Report on the World Health Situation, 1957-1960* (World Health Organization, 1963) shows that, in 1960 alone, approximately 3 880 000 persons in the United States received vaccination against tetanus.

### Middle America

According to statistics made available to WHO for the years 1951-60, the absolute number of deaths from tetanus in Middle America ranged from 2994 in 1951 to 4757 in 1960 among a population of 42 000 000 that was covered by registration (WHO *Annual Epidemiological and Vital Statistics, 1950-1964*). However, these figures must be considered very incomplete, since before 1945 deaths from tetanus were reported by but 14 countries in this region. Later, however, the number of reporting countries was raised, first to 18, then to 22.

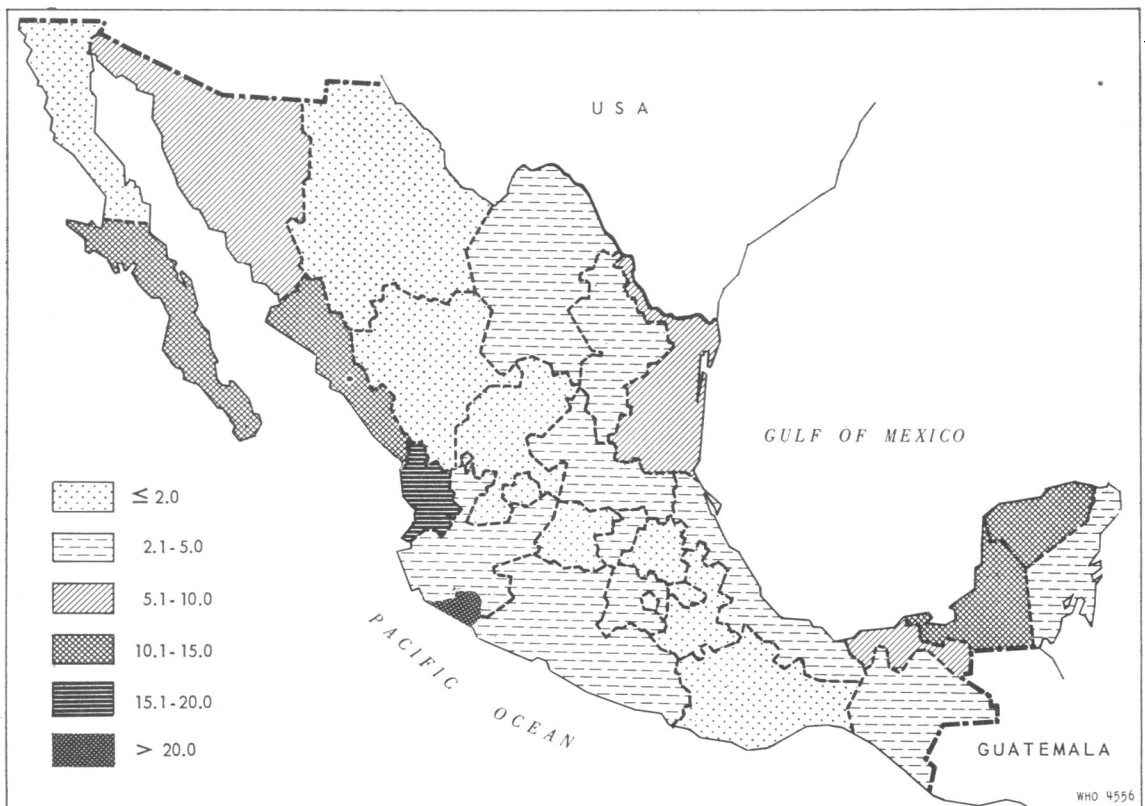
The highest mortality rate from tetanus that was recorded during the decade 1951-60 was that of the Dominican Republic (63.3 deaths per 100 000 population). In 1960, tetanus was listed among the ten principal causes of death in both Costa Rica and Mexico, in which two countries it accounted, respectively, for 2.5% and 0.57% of the total number

of deaths (World Health Organization, 1963). In Mexico, tetanus was responsible for more deaths than leprosy, scarlet fever, meningitis, typhus exanthematicus or rabies (*Bol. epidem. (M ex.)*, 1952-63).

The decennial mortality rate from tetanus per 100 000 population during the decade 1951-60 was highest in the Dominican Republic (63.33), Nicaragua (32.8), Costa Rica (21.7), Panama (19.1) and El Salvador (15.2) and lowest in Guatemala (2.6), as shown by the statistics made available to WHO for the years 1950-64.

Although this difference in recorded mortality rates is due, largely, to differences in the reliability and completeness of the reports, they also reflect, to some extent, actual differences in the distribution of the disease. Such variations may be found even within a single country. Fig. 2 shows that, in Mexico, for example (*Bol. epidem. (M ex.)*, 1952-

FIG. 2  
GEOGRAPHICAL DISTRIBUTION OF TETANUS IN MEXICO DURING THE PERIOD 1949-61<sup>a</sup>



<sup>a</sup> Average annual mortality rates per 100 000 inhabitants (Amezquita Urias, 1964).



63; Silva Martinez, 1964), where the number of recorded deaths from tetanus doubled from 1950 to 1960, and in 1959 and 1960 reached the totals of 2487 and 2570, respectively. Amezcuita Urias (1964) observed, during the years 1956-60, real foci of tetanus in several Mexican states. In Nayarit, the tetanus mortality rate per 100 000 population was 70.96; in Colima, 35.76; in Sinaloa, 20.2; in Jalisco, 20.22; in the territory of Baja California Sur, 16.16; in Tamaulipas, 15.18; in Campeche, 13.26; and in Nuevo León, 11.28. In Zacatecas, on the other hand, it was but 2.1, approximately, and in the state of Mexico it was 0.5, and in the Federal District it was 0.9 (*Bol. epidem. (Méx.)*, 1952-53). Malpica (1961) considered that about 60% of all Mexican deaths from tetanus occurred in the state of Tamaulipas where, as noted above, the death-rate from this infection was found to be 15.18 per 100 000 population. During the period 1951-60, the tetanus mortality rate per 100 000 for all of Mexico was 6.6.

It should be noted that the number of cases of tetanus that occurred per year in any given area of Mexico was rather consistent. Gomez et al. (1960), for example, have reported that, in the State of Nayarit, there were between 34 and 54 cases of tetanus each year from 1948 to 1958. This observation indicates that, in such foci of infection, conditions must be particularly favourable for its persistence.

Amezquita Urias (1964) noted that, among the 2487 fatal cases of tetanus in Mexico in 1959, there was a preponderance of males (1389, or 55.87%) over females (1098, or 44.13%).

In the Caribbean area, the incidence of tetanus is approximately the same as in Mexico. For example, Forde & Williams (1960) have estimated that the tetanus morbidity rates in Barbados in the years 1951 through 1954 were, respectively, 13.1, 22.8, 12.5 and 22.5. The same investigators report having treated 27 patients, of whom eight (29.6%) died. Other studies in Central America and the Caribbean have shown tetanus case fatality rates that are even higher (Francisco, 1944; Taxay, 1960; Back, 1960; Montgomery, 1961; Miranda & Hempel, 1962).

Amezquita Urias (1964) has reported that, of the 2487 patients who died of tetanus in Mexico in 1959, 1624 (65.3%) were less than one year of age. Similarly, Miranda & Hempel (1962) have reported that, of 190 patients with tetanus admitted to a hospital in Costa Rica in a six-year period, 44 (23.1%) were newborn.

Unlike the situation in the USA, there is no distinct seasonal distribution of tetanus in Mexico,<sup>1</sup> as shown below:

Season	Number of cases	Percentage
December-February	1 773	23.0
March-May	1 826	23.7
June-August	2 121	27.6
September-November	1 969	25.6

For a period of ten years, the highest proportion of admissions to hospital for tetanus in Mexico (9.7%) occurred in July. In Antigua, on the other hand, the highest incidence of tetanus has been observed during the first and second quarters of the year, when the sugar crop is harvested (Uttley, 1959). The necessity for active immunization against tetanus has been stressed by many workers in Mexico, Central America and the Caribbean, several of whom have proposed definite programmes for the control of tetanus (Gomez et al., 1960; Malpica, 1961; Amezcuita Urias, 1964; Silva Martinez, 1964). Immunization of the population with tetanus toxoid or diphtheria-pertussis-tetanus (DPT) vaccine has been initiated in Bolivia, Brazil, British Guiana and the islands of Bermuda, Barbados and Cuba.

#### South America

Since, prior to 1960, such countries as Argentina, Brazil, Peru and Uruguay reported only those deaths from tetanus that occurred in the principal cities, while for Bolivia no data were provided at all, little is known concerning the actual situation of tetanus in South America. Consequently, the mortality rates that have been calculated on the basis of WHO statistics for South America can be considered as approximations only. The calculated average mortality rate for tetanus in the entire continent is, of course, greatly influenced by this situation. However, if Argentina and Brazil are excluded from the calculations, it becomes apparent that the South American rate of mortality from tetanus would be about as high as that for Middle America—that is, approximately 8.50 per 100 000 population.

The apparent increase in tetanus mortality for the entire South American continent may be attributed to an improvement in registration. According to the admittedly incomplete data available to WHO, based on an average covered population of 76 000 000, approximately 27 000 deaths from tetanus were recorded during these 14 years, indicating a death-rate from tetanus of at least 3.5 per 100 000 popula-

<sup>1</sup> *Bol. epidem. (Méx.)*, 1952-63.

tion. If this rate were to be applied to the entire population of South America (that is, about 125 millions), the number of deaths for 10 years would exceed 40 000. More recent reports from several authors, however, indicate that the true mortality figures are even higher. For example, in but five years (1957-61), 4989 cases of tetanus were recorded by principal hospitals in Venezuela. Of this number, 2638 (47.46%) terminated fatally (Figueroa & Romero, 1963). In 1960-61, the mortality from tetanus in all of Venezuela, as indicated by these authors, was 12.2 per 100 000 population, being as high as 72 in the State of Portuguesa, 28.8 in the State of Cojedes, and 27.9 in the State of Yaracuy. The lowest mortality rate for tetanus (2.4 per 100 000 population) was observed in the Federal District.

The figures from Venezuela show slight differences in incidence between the sexes. In the age-groups from 0-1 years to 20-24 years, as well in the age-groups over 45 years, there was a higher incidence in males, while female patients were more numerous in the age-groups from 25 to 44 years.

In the 1200-bed Hospital das Clinicas at the School of Medicine of the University of São Paulo, in São Paulo, Brazil, about 120 tetanus patients have been treated each year for the last 16 years (Nenes & Tranchesi, 1948; Bahia, 1953; Pinheiro, 1957, 1960, 1962).

Pinheiro (1960) has shown that, in the State of São Paulo, with a population of approximately 15 000 000, there were 13 299 deaths from tetanus during the period 1950-58, for an annual mortality rate per 100 000 of approximately 9.8. Of these deaths, 1015 occurred in the capital itself, whereas 12 284 (92.36%) occurred in the surrounding State.

From the case-histories of 1903 patients with tetanus admitted to one São Paulo hospital during a 16-year period, 75.7% of the cases occurred in children under 14 years of age and in women and manual workers under 20 years of age. About 78% of the patients were Caucasians. There was a remarkable predominance of males over females (about 2 : 1). The disease usually developed after the patient had experienced minor injuries, deliveries, abortions or chronic ulcerations, but many patients presented no visible site of infection (Pinheiro, 1957; Veronesi, 1960). Among 148 cases of tetanus treated by Salvaraglio & Ebole (1950), 7 (4.73%) were post-surgical. Zubillaga (1952) has reported that 32 (40%) of 80 patients with tetanus contracted the disease after infestation with the burrowing flea *Sarcopsylla penetrans*.

Long ago, von Reuss (1927) stated that, in tropical areas, tetanus was responsible for from 10% to 25% of all child mortality. A study conducted by Oropeza (1937) in Venezuela showed that 7% of all deaths of newborns were due to this infection.

Data recently collected by Mattos (1962) reveal that, from 1957 to 1961, about 5000 cases of tetanus neonatorum were registered in the Brazilian State of São Paulo. For example, in 1960, there were 60.2 cases of this disease per 1000 live-births, and in 1961 this rate rose to 83.7 per 1000. Mattos considers that, in Brazil, there are at least 7000 cases of tetanus neonatorum annually, and Oliveira (1958) has reported that, between 1936 and 1945, 941 cases of tetanus neonatorum were reported for Rio de Janeiro alone, for a yearly average of 94 cases. In Chile, of 141 cases of tetanus in a Santiago hospital, 29 (20.5%) occurred in the newborn (Casorzo & Figueroa, 1951). Later, La Scala (1958) reported that 56 cases of tetanus neonatorum had been admitted to the same hospital during the years 1949 to 1957. Figueroa & Romero (1963) stated that about 57% of all tetanus patients reported in Venezuela during the years 1957 to 1961 were less than one year of age.

A number of other reports from South America show that tetanus is fairly common in Uruguay (Salvaraglio & Ebole, 1950; Fonseca et al., 1961), Venezuela (Zubillaga, 1952), Argentina (Aguileiro, Brahiero & Ghigliazza, 1960), and Chile (Rojas et al., 1960). In Argentina, for example, during 1960, tetanus attacked 469 persons (morbidity rate of 2.34 per 100 000 population) and was considered the fifteenth most important communicable disease in that country (World Health Organization, 1963).

Kloetzel & Monteiro (1963), who performed a clinical and laboratory study on tetanus in São Paulo, Brazil, reported that the cause of death in tetanus remains unknown, and that present-day treatment of this disease is inadequate; almost 60% of untreated patients recovered. In general, the case-fatality rate for tetanus in South America seems to range from 35% (Pinheiro, 1957; Veronesi, 1960; Fonseca et al., 1961; Kloetzel, 1963) to 54% (Salvaraglio & Ebole, 1950).

The high case-fatality rate in tetanus neonatorum has been noted by several authors: Carvalho & Nascimento (1950) set it at 92.5%; Casorzo & Figueroa (1951) show 79%; Zubillaga (1952) gives 65%; Pinheiro (1957) sets it at 84%; La Scala (1958) sets it as high as 89.28%; Veronesi (1960) at 83%;

Pinheiro (1962) at 76.9%, and Figueroa & Romero (1963) at 60%.

The geographical distribution of tetanus in South America remains to be investigated. However, there is evidence that, in Venezuela, the States of Portuguesa, Cojedes, Yaracuy, Barinas, Amazonas, Sucre, Trujillo, and Apure are foci of infection (Figueroa & Romero, 1963), as are the provinces of São Paulo and Maceio in Brazil (Mattos, 1962).

As one moves southward from the equator, the seasonal distribution of tetanus is found to be more and more distinct (Veronesi, 1960), with the highest incidence of the disease falling in September to November (spring) and the lowest in April-June (autumn).

Public awareness of tetanus as a public health problem in South America has been growing steadily during the past 20 years (Veronesi, 1960; Figueroa & Romero, 1963). Immunization with tetanus toxoid or with diphtheria-pertussis-tetanus (DPT) vaccine has been initiated in some parts of Argentina and Brazil. In view of the high morbidity from tetanus neonatorum, recommendations for the vaccination of pregnant women in Brazil were made by Lacaz et al. in 1955.

As may be concluded from the *Second Report on the World Health Situation, 1957-1960* (World Health Organization, 1963), the progress of the control of tetanus in the Americas during the period 1951-60 has been rather slow, except in the USA and Canada.

#### ASIA

In Asia, the existence of tetanus has been known for centuries, and the Indian Clinical Research Advisory Committee (Indian Research Fund Association, 1946) suggested that there was urgent need to study the problem. More recently, Tateno, Suzuki & Kitamoto (1961) have reviewed the situation regarding tetanus in Japan, and the first International Conference on Tetanus was held in Bombay, India, in November 1963.

Before 1950, only five countries in Asia recorded deaths from tetanus and reported them to WHO: Ceylon, Hong Kong, Israel, Japan and Thailand. During the decade 1951-60, the number of States that reported tetanus to WHO never exceeded 32, covering not more than 40% of the population of Asia. During this entire period, no data were available for Afghanistan, Burma, China (mainland), Iran, Mongolia, or Viet-Nam, while Ceylon, India, Indonesia, Laos and Cambodia supplied only in-

complete figures that had been collected from hospitals in the principal cities. Consequently, the figures shown in WHO statistics from 1960 to 1964 represent but a relatively small proportion of the tetanus cases that actually occurred in Asia during that period.

The highest mortality rates from tetanus per 100 000 population for the indicated period were 61 (Macao, 1952), 44 (Goa, Damao, Diu, 1952), 26 (Taiwan, 1954), 9 (Philippines, 1960), 6 (Federation of Malaya, 1961), and so on. The lowest tetanus mortality rates for Asian countries in the period specified were those of Israel (0.37, 1960) and Japan (0.64, 1960). The average tetanus mortality rate per 100 000 population for the entire covered Asian population for the decade 1951-60 was 2.7, ranging from 2.4 in 1958 to 3.8 in 1952. The minimum mortality rate for tetanus cases in the 32 countries listed in the *Annual Epidemiological and Vital Statistics* published by WHO covering the period under review was 2.3 per 100 000 population, with approximately 14 000 deaths; the highest morbidity rate was 3.0, with approximately 19 000 deaths. The number of deaths from tetanus in the Asian countries that reported to WHO, excluding India, was 6700 in 1954 and 4800 in 1960. However, if the deaths reported in India for 1958 are included (*Vital Statistics of India, 1960*) the figure for 21 States is 15 500, yielding a mortality rate per 100 000 population of 2.4. Despite the incompleteness of the data, it can be assumed that, from a population of 645 000 000, there were at least 155 800 deaths from tetanus in 21 Asian countries during the decade 1951-60. Moreover, if a mortality rate of 2.3 to 2.8 holds true for all of Asia, which has an estimated population of 1 532 000 000, there must have been about 350 000 to 420 000 deaths from this disease during the decade in question.

As noted above, however, these calculations are based on very incomplete data. Indeed, the mortality rate from tetanus in many Asian countries will exceed 2.8.

The following figures<sup>1</sup> show that there has been a constant increase in admissions to hospital for tetanus in both the Punjab and Rajasthan during the years 1956-62, the numbers for 1961 being almost 2.5 times those for 1956.

<sup>1</sup> From the annual reports (1962-63) on the public health administration for the Punjab and from a statement issued by the National Institute of Communicable Diseases, New Delhi, showing the number of patients treated for tetanus in the 25 State Public Hospitals in Rajasthan during the years 1950-61.

TABLE 5  
TETANUS ADMISSIONS IN SOME HOSPITALS OF INDIA

Author	Town	Hospital	Year(s)	No. of tetanus patients	Percentage of all admissions
Patel, Mehta & Nanavati (1963)	Bombay	King Edward Memorial Hospital	1954-1962	4 733	1.9
Vakil et al. (1963)	Bombay	J.J. Group of Hospitals	1954-1962	1 852	1.4
Vaishnava et al. (1964)	Delhi	Irwin Hospital	1960-1963	2 030	—
Ayyar, Ramakrishnan & Singh (1963)	Delhi	Safdarjang Hospital	1961	249	1.2
Srivastava & Chatterji (1961)	Agra	S.N. Hospital	1952-1959	702	0.6
Mathur & Singh (1963)	Lucknow	Gandhi Memorial Hospital	1951-1958	974	—
Bhatt & Anwikar (1962)	Nagpur	Medical College	1951-1956 1958-1959	888	—
Kochhar (1960)	Amritsar	Medical College	1955-1958	200	2.2
Barua (1961)	West Bengal	Hooghly Sadar A.G. Hospital	1957-1960	280	1.8
Laha & Vaishya (1963)	Gwalior	G.R. Medical College and J.A. Group of Hospitals	1954-1961	1 024	4.8

Year	Punjab	Rajasthan
1956	1 062	1 107
1957	1 501	941
1958	1 794	1 242
1959	2 001	1 387
1960	2 470	2 080
1961	2 681	2 756
1962	2 984	

The tetanus morbidity rate in the Punjab has gradually increased from 6.2 per 100 000 in 1956 to 16.5 in 1961. With regard to Rajasthan, it is of interest to note that, in 1951, only 319 tetanus cases were reported from the State Public Hospitals,<sup>1</sup> whereas the corresponding number for 1961 was 2756, or 8.6 times as high.

However, this phenomenal increase may be more apparent than real, quite probably being attributable to factors such as the improvement of public health records, the compulsory hospitalization of severe cases of this disease, and the gradual improvement in the health consciousness of the population and in its attitude toward the public health services.

The situation is very much the same in other parts of India. For example, in Goa, Damao and Diu, the average mortality per 100 000 population during

the period 1951-58 was estimated to be 14.8, with a peak of 44.06 in 1952. However, in some rural areas, there are foci in which tetanus is the fourth-ranking cause of death, with a mortality rate of 90.8 per 100 000 (Gordon, Singh & Wyon, 1961; Parikh, 1963) or even more than 100 per 100 000 (Pai, 1963). Many Indian hospitals have an extremely high number of tetanus patients (Table 5).

All of these data suggest that India should be included in the zone in which the tetanus mortality rate is between 5 and 10 per 100 000 population. This estimate has been substantiated by surveys conducted recently in some rural and urban areas of India by Joag (1963), who found that the tetanus mortality rate per 100 000 was approximately 9.7.

The role of tetanus as one of the leading causes of death in Asia was stressed by Silva (1960), who estimated that, in Ceylon, this infection strikes more than 1500 persons each year, and that the mortality rate from this disease is not less than 5 per 100 000 inhabitants.

In Abadan, Iran, tetanus has been listed as the twelfth most important cause of all deaths and as the sixth most important cause of all infant deaths, the gross mortality rate from this disease being approximately 9.9 per 100 000 population.<sup>2</sup> Reports

<sup>1</sup> From the annual reports (1962-63) on the public health administration for the Punjab and from a statement issued by the National Institute of Communicable Diseases, New Delhi, showing the number of patients treated for tetanus in the 25 State Public Hospitals in Rajasthan during the years 1950-61

<sup>2</sup> Pakdel (1961), *The main causes of death in Abadan among company employees and their dependants*. Seventh meeting, Persian Gulf Medical Society. (Unpublished.)

on tetanus appear from time to time in the Iranian medical literature (Yazdani, 1954; Binechvar & Ghavampour, 1954).

In Singapore, data collected from the General Hospital for three years by Gwee & Nadarajah in 1960 showed that 77 to 87 patients with tetanus had been admitted during each year. The tetanus morbidity rate per 100 000 population in that city increased from 5.2 in 1957 to 6.4 in 1959. These authors also observed a rise in the tetanus case-fatality rate during the years 1957-59, particularly in the newborn.

In Indonesia, also, tetanus is one of the principal causes of death (Indonesia, 1957, 1958). During the period 1957-58, of every 1000 patients deceased in the principal hospitals, 38 died from tetanus (3.8%). Altogether, in only these two years, 1565 deaths from tetanus were recorded, 703 (44.9%) of which were from tetanus neonatorum. According to Poesponegoro & Ranti (1959), during a period of only nine years (1949-57), 1062 children with tetanus were admitted to the Paediatric Department of the General Hospital of Djakarta, of whom 573 (53.9%) died. These hospitalized children included 578 newborns. De Reus (1963) has reported seeing, in three hospitals on the island of Deli, Indonesia, between 1956 and 1961, 257 tetanus patients, of whom 102 were newborn.

Very little is known concerning tetanus in mainland China. According to Young-En Kao (1948), however, among the specific infectious diseases that were registered in the National Kweyang Medical College and Hospital between 1939 and 1945, there were 51 cases of tetanus neonatorum, representing 1.14% of all admissions, thus exceeding the incidence of smallpox, scarlet fever, mumps, erysipelas, rheumatic fever, rabies, cholera and septicaemia. The same author (1951) has observed tetanus neonatorum in Nanking.

The rank of tetanus among other important causes of death in Asia has not yet been determined, but in Japan, where Tateno, Suzuki & Kitamoto (1961) have recently investigated this disease, it was found that, in 1958, tetanus killed more people than did Japanese encephalitis, poliomyelitis, epidemic meningitis, pertussis, scarlet fever, typhoid fever, or rabies; indeed, the number of deaths from tetanus was almost tenfold greater than that from typhoid fever. Similarly, the *Second Report on the World Health Situation* (World Health Organization, 1963) shows that, in Ceylon, tetanus kills more people than either poliomyelitis or rabies.

While no reliable data on the actual incidence of tetanus in Burma are available, some observers (unpublished report to WHO) have noted that, during 1963, the Rangoon General Hospital admitted 217 cases of tetanus, 81 of which terminated fatally; neonatal tetanus accounted for 63 admissions and 40 deaths in this series. A report from Turkey (World Health Organization, 1963) shows that, in 1960, there were 445 deaths from tetanus, as against 442 from typhoid fever and 50 from rabies.

There is no country in which the distribution of tetanus is uniform. As a rule, the principal foci of infection are to be found in rural areas located in plains with fertile soil, along rivers, or in coastal regions where the climate is damp and warm. According to Tateno, Suzuki & Kitamoto (1961), there are but three prefectures in Japan (Chiba, Bagana and Miyasaki) with tetanus morbidity rates of more than 2.0 per 100 000 population (Fig. 3). All of these prefectures border the Pacific and have warmer climates than do those that are situated along the coast of the Sea of Japan.

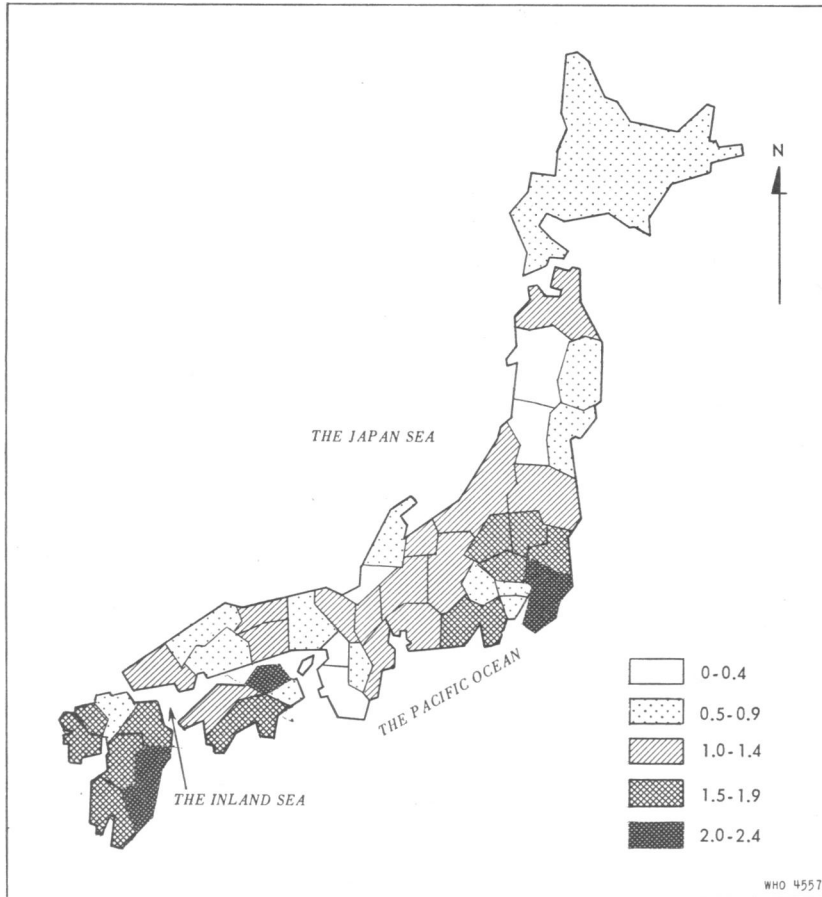
The area distribution of tetanus has been commented upon by Beisser (1960) in Indonesia and has also been studied in the Punjab (unpublished report to the World Health Organization).

The tetanus case-fatality rates for Asia are shown in Tables 6 and 7. It is possible, however, that the actual figures may be rather higher than those shown in these two tables, since in India and several other countries, seriously ill patients are sometimes removed from hospital to die at home, for religious reasons. Generally, the fate of such patients is unknown, and they are recorded in the hospital records as having "left against medical advice".

The data presented in Tables 6 and 7 show that the case-fatality rate of tetanus varies widely from place to place, from hospital to hospital, and from one period to another. The highest case-fatality rate (92.2%) was noted for Goa, Damao and Diu, in India, followed by 86.3% in North Borneo, 78.4% in Japan, and 76.1% in the Philippines. The lowest case-fatality rate (13.7%) was reported from the French settlements in India.

In Asia, as in Africa and the Americas, the population groups that are most subject to attack by tetanus include children in the 1-to-15-year-old age bracket, agricultural workers, women, and the newborn (Laha & Vaishya, 1963; Patel & Mehta, 1963; Vaishnava et al., 1964). The prevalence of tetanus is usually higher in males than in females at all ages except 15-45 years (Yeoh, 1960; Kochhar,

FIG. 3  
GEOGRAPHICAL DISTRIBUTION OF TETANUS IN JAPAN<sup>a</sup>



<sup>a</sup> Morbidity from tetanus per 100 000 population (Tateno, Suzuki & Kitamoto, 1961).

1960; Bhatt & Anwikar, 1962; Patel & Mehta, 1963; Laha & Vaishya, 1963).

Most patients contract tetanus as the result of injuries to the leg or arm. Patel & Mehta (1963) found that, of 2007 cases of tetanus, 728 (36.2%) occurred after injury to the legs, 147 (7.3%) to the arms, 297 (14.8%) to the trunk, and 79 (3.9%) to the face and head. Other investigators also have found that tetanus infection usually occurred after injuries to the legs: 69% according to Yeoh (1960), 55.2% according to Tateno, Suzuki & Kitamoto (1961), and 51.5% according to Vaishnav et al. (1964).

Tetanus neonatorum (Table 8) and also post-natal and post-abortive tetanus (Table 9) are important in many Asian countries, not only because of the large number of cases, but because of the high case-fatality rates. Table 10 shows that, in some of the studies represented, tetanus neonatorum accounted for 1883 (18.7%) of the 10 088 cases of tetanus included in 18 studies.

In India, very little progress has been made in decreasing the case-fatality rate in tetanus neonatorum (Athavale, 1963). In Taiwan, a statistical study of the causes of death among children admitted to the Paediatric Department of the National

TABLE 6  
CASE FATALITY FROM TETANUS IN SOME COUNTRIES OF ASIA

Country	Year(s)	No. of cases	No. of deaths	Case fatality (%) <sup>d</sup>
North Borneo <sup>a</sup>	1951	23	20	(86.3)
Cambodia <sup>a</sup>	1951	23	5	(21.7)
Ceylon <sup>a</sup>	1951	1 150	346	30.0
Ceylon	1955-1957	2 817	1 100	39.0
India				
Punjab <sup>b</sup>	1956-1962	14 493	3 972	27.4
Rajasthan <sup>c</sup>	1960	2 080	808	38.8
West Bengal <sup>c</sup>	1960	1 024	574	56.0
French Settlements <sup>a</sup>	1951-1952	167	23	13.7
Goa, Damao and Diu <sup>a</sup>	1951	284	262	92.2
Iraq <sup>a</sup>	1951-1953	1 004	266	26.5
Israel <sup>a</sup>	1951-1953	116	39	33.6
Japan <sup>a</sup>	1951-1953	4 394	3 447	78.4
Jordan <sup>a</sup>	1951	37	15	(40.5)
Macao <sup>a</sup>	1951	183	95	51.9
Philippines <sup>a</sup>	1951	1 697	1 292	76.1
Ryukyu Islands <sup>a</sup>	1951	200	42	21.0
Singapore <sup>a</sup>	1951-1952	159	73	45.9
Viet-Nam <sup>a</sup>	1951	213	41	19.2
Viet-Nam <sup>a</sup>	1960	472	112	23.7

<sup>a</sup> *Epidem. Vital Statist. Rep.*, 1954, 7, 263-265.

<sup>b</sup> Annual reports on the public health administration for the Punjab, 1960-62.

<sup>c</sup> *Vital Statistics of India*, 1960.

<sup>d</sup> The figures in parentheses are percentages of numbers less than 100.

Taiwan University Hospital showed tetanus to be among the most important (Lue, Hung-Chi, 1960). In Thailand, although tetanus is not yet a notifiable disease, an epidemiological sampling study conducted by Stahlie (1960) showed that, among 2344 children studied, 37 died from various causes, and of these 37 patients, 19 had presented the symptoms of tetanus. Stahlie considers tetanus to be definitely one of the leading causes of infant mortality and has appealed that it be made notifiable. In India, in the rural Punjab, Gordon, Singh & Wyon (1961) found that, of 33 patients who died of tetanus, 30 were apparently newborn infants.

Situations of this sort exist in many other places in Asia in which health services, especially maternal and child health institutions, are lacking, and in

which there is an absence of health education but widespread poverty, religious prejudices, and traditional unhygienic customs and habits (Yodh & Shah, 1956; Menon, 1960; Harper, 1961; Gwee & Lee, 1962). Most mothers in the rural parts of Asia are delivered of their infants with the help of local midwives such as the *dais* of India, the *dukun* of Indonesia, and the *monthamyae* of Thailand, or with that of elderly relatives who are frequently ignorant of infection and who use unsterilized scissors, knives, or other sharp instruments to sever the umbilical cord. In some places, wounds are treated with dust, the ashes of cow dung, or even with earth (Silva, 1960; Gordon, Singh & Wyon, 1961).

De Reus (1963) has stated that the high incidence of tetanus neonatorum in Indonesia is principally

TABLE 7  
CASE FATALITY FROM TETANUS IN ASIA ACCORDING TO VARIOUS AUTHORS

Country	Author	No. of cases observed	No. of deaths	Case fatality (%) <sup>a</sup>
Ceylon	Natkunam (1960)	89	36	(40.4)
Ceylon	Silva (1960)	384	110	28.6
India	Lewis et al. (1954)	40	29	(72.5)
India	Hanna (1958)	77	36	(51.9)
India	Kochhar (1960)	200	92	46.0
India	Ghosh & Soni (1961)	248	151	60.8
India	Sinha (1961)	91	35	(38.4)
India	Srivastava & Chatterji (1961)	702	329	46.8
India	Shah et al. (1962)	214	95	44.4
India	Jain (1962)	63	19	(30.1)
India	Bhatt & Anwikar (1962)	888	408	45.9
India	Limaye (1962)	144	61	42.3
India	Arora, Desai & Kazi (1963)	170	68	40.0
India	Ayyar, Ramakrishnan & Birenda Singh (1963)	249	121	48.6
India	Barua (1963)	383	108	28.2
India	Basu (1963)	114	41	35.9
India	Mahadevan (1963)	2 021	747	37.0
India	Modi (1963)	554	243	43.8
India	Sharma (1963)	510	229	44.9
India	Vaishnava et al. (1964)	2 030	954	47.0
India	Vakil et al. (1963a)	293	114	39.0
India	K.E.M. Hospital Group (1963a)	4 839	2 216	45.8
Indonesia	Poesponegoro & Ranti (1959)	1 062	573	53.9
Japan	Tateno, Suzuki & Kitamoto (1961)	945	755	79.9
Singapore	Yeoh (1960)	130	63	48.4
Singapore	Gwee & Nadarajah (1960)	272	109	40.0
Viet-Nam	Tran Van Bang & Nguyen Duy San (1960)	265	115	43.4

<sup>a</sup> The figures in parentheses are percentages from numbers less than 100.

attributable to local customs and rituals associated with childbirth. In many places, the cord is cut with a bamboo sliver and then dressed with a mixture of lemon juice, coconut oil and salt or with some similar preparation. De Reus thinks that this custom will not disappear in the near future and therefore believes that the active immunization of mothers with tetanus toxoid is indispensable if tetanus neonatorum is to be controlled.

Some studies have shown that post-natal and post-abortive tetanus account for from 3.3% (Patel et al., 1960) to 22.2% (Jain, 1962) of all cases of tetanus (Table 9). The case-fatality rate in this case is reported as ranging from 64.2% (Patel, 1960) to 72.4% (Bhatt & Anwikar, 1962).

A relatively large number of cases of this disease occurring after injections, vaccinations, and operations have been reported from Asia by many



TABLE 8  
CASE FATALITY IN TETANUS NEONATORUM IN ASIA,  
AS REPORTED BY VARIOUS INVESTIGATORS

Country	Author	No. of tetanus neonatorum cases	No. of deaths	Case fatality (%) <sup>a</sup>
Ceylon	Silva (1960)	21	15	(71.4)
Ceylon	Natkunam (1960)	9	9	(100)
India	Lewis et al. (1954)	12	3	(25.0)
India	Matveyev & Paul (1959)	47	41	(87.2)
India	Nazareth & Edibam (1959)	16	9	(56.2)
India	Kochhar (1960)	42	39	(92.8)
India	Patel et al. (1960)	308	272	88.3
India	Barua (1961)	54	39	(72.2)
India	Ghosh & Soni (1961)	88	76	(86.3)
India	Srivastava & Chatterji (1961)	108	79	73.1
India	Syngal (1961)	18	14	(77.8)
India	Shah et al. (1962)	9	8	(88.9)
India	Jain (1962)	23	17	(73.9)
India	Bhatt & Anwikar (1962)	71	61	(85.9)
India	Basu (1963)	29	20	(68.9)
India	Ayyar, Ramakrishnan & Birenda Singh (1963)	81	50	(61.7)
Indonesia	Poesponegoro & Ranti (1959)	578	447	77.3
Iraq	Critchley (1958)	364	263	72.2
Japan	Tateno, Suzuki & Kitamoto (1961)	7	4	(57.1)
Singapore	Loh Siew Gek (1951)	174	159	91.3
Singapore	Gwee & Nadarajah (1960)	27	20	(74.0)
Viet-Nam	Tran Van Bang & Nguyen Duy San (1960)	1	1	(100)
Total		2 087	1 646	78.9

<sup>a</sup> The figures shown in parentheses are percentages of numbers less than 100.

authors, among them Tran Van Bang & Nguyen Duy San (1960), Murti, Bhaskran & Rajyalakshmi (1961), Tateno, Suzuki & Kitamoto (1961), Bhatt & Anwikar (1962), Patel & Mehta (1963) and Heredia (1963). This circumstance bears unhappy witness to the fact that many practitioners, and even some clinicians, underestimate the risk of tetanus.

Special attention should be given here to otogenous tetanus, a condition that is often observed in India (Kochhar, 1960; Natkunam, 1960; Barua, 1961; Bhatt & Anwikar, 1962; Wagle, 1963). Ghosh

(1950), for example, has stated that 70% of children with tetanus also suffered from otitis. Toxigenic strains of *Clostridium tetani* have been isolated by some workers from the ear discharges of some children with tetanus (Hazra & Agnihotri, 1960; K.E.M. Hospital Group, 1963b; Sen, Vaishnava & Passey, 1963). In a series of tetanus patients treated by Srivastava & Chatterji (1961), the proportion of otogenous tetanus was 11.6%; whereas the corresponding figure given by Patel & Mehta (1963) was 20.2%.

TABLE 9  
POST-NATAL AND POST-ABORTIVE TETANUS IN ASIA, AS REPORTED  
BY VARIOUS INVESTIGATORS

Country	Author	Total No. of cases observed	Post-natal and post-abortive cases	
			No.	% <sup>a</sup>
India	Kochhar (1960)	200	14	7.0
India	Patel et al. (1960)	2 007	67	3.3
India	Barua (1961)	280	20	7.1
India	Srivastava & Chatterji (1961)	702	61	8.7
India	Shah et al. (1962)	214	26	12.1
India	Jain (1962)	63	14	(22.2)
India	Bhatt & Anwikar (1962)	888	113	12.7
Japan	Tateno, Suzuki & Kitamoto (1961)	183	17	9.3
Singapore	Yeoh (1960)	130	3	2.3
Viet-Nam	Tran Van Bang & Nguyen Duy San (1960)	265	14	5.3

<sup>a</sup> The figures shown in parentheses are percentages of numbers less than 100.

The seasonal distribution of tetanus in Asia varies with the area. The seasons of peak incidence of this disease are usually closely connected with the warm, damp season and the time of the most intensive work in the fields. In Japan (Tateno, Suzuki & Kitamoto, 1961), where the winters are cold, admissions to hospital for tetanus are highest during summer (June and July), while in India (Barua, 1961; Vaishnava et al., 1964), the greatest number of tetanus patients is registered during the monsoon period (July and August). On the other hand, Laha & Vaishya (1963) report that the highest number of tetanus patients in Gwalior, India, came to hospital during December. In Indonesia, Poesponegoro & Ranti (1959) found that most of the children suffering from tetanus in Djakarta were admitted to hospital during April and May.

A tendency toward an increase in the incidence of tetanus has been observed in India, the Philippines, Indonesia, and some other Asian countries. On the other hand, Cyprus, Israel, and Taiwan have recently initiated the mass immunization of children with tetanus toxoid and have achieved good results. In Taiwan, the mortality rate from tetanus per 100 000 population has decreased from the 1954 level of 25.8 to 3.7 in 1960. In Israel, the 1953 level of 1.9 had been reduced to 0.4 by 1960. In this connexion, it is of interest that, strangely enough, the incidence

of tetanus in Japan has been decreasing constantly from 1947 through 1960, without any specific measures of immunization being applied (Tateno, Suzuki & Kitamoto, 1961). These authors suggest that this decline could be a consequence of the mass use of antibiotics and chemotherapeutic agents by the Japanese population.

Campaigns of immunization with diphtheria-pertussis-tetanus (DPT) or diphtheria-tetanus (DT) vaccines have been launched in Singapore, Hong Kong, Iran and Jordan, and similar campaigns are being planned for Thailand, Viet-Nam, Indonesia and Burma (World Health Organization, 1963).

#### EUROPE

Although the epidemiology of tetanus has been studied more intensively in Europe than elsewhere (Eckmann, 1960; Matveev, 1960), even on that continent there are some countries that became aware of the problem only within the last 10 or 20 years. Table 11, which has been prepared on the basis of the data available to WHO, shows the changing trends of tetanus infection in some European countries during the last four decades. Inspection of this table reveals that the mortality rate from tetanus has been decreasing gradually; even the Second World War made no significant change in this process.

TABLE 10  
TETANUS NEONATORUM IN SOME COUNTRIES OF ASIA

Country	Author	Total No. of cases observed	No. of tetanus neonatorum cases	Percentage of tetanus neonatorum cases <sup>a</sup>
Ceylon	Natkunam (1960)	89	9	(10.1)
Ceylon	Silva (1960)	2 738	298	10.9
India	Sheth (1956)	105	19	18.1
India	Kochhar (1960)	200	42	21.0
India	Patel et al. (1960)	2 007	308	15.3
India	Barua (1961)	280	54	19.3
India	Ghosh & Soni (1961)	248	88	35.5
India	Srivastava & Chatterji (1961)	702	110	15.6
India	Shah, Shah & Damany (1962)	214	9	4.2
India	Jain (1962)	63	23	(36.5)
India	Bhatt & Anwikar (1962)	888	71	8.0
India	Ayyar, Ramakrishnan & Birenda Singh (1963)	249	81	32.5
India	Basu (1963)	114	29	25.4
India	Vakil et al. (1963)	293	17	5.8
Japan	Tateno et al. (1961)	183	7	3.8
Singapore	Yeoh (1960)	130	1	0.8
Iran	Pakdel (1961)	18	14	(77.8)
Indonesia	Vital Statistics (1957-1958)	1 567	703	44.8
		10 088	1 883	18.7

<sup>a</sup> The figures in parentheses are percentages from numbers less than 100.

Indeed, the only countries in which the number of cases of tetanus increased between 1941 and 1950 were Italy, Finland, the Netherlands and Switzerland. In the last-named country, this apparent increase may have occurred because the notification of cases of tetanus occurring after minor injuries was initiated only in 1942; prior to that year, only post-partum, post-abortive, and neonatal cases were notifiable.

A remarkable fall in the number of deaths from tetanus was observed in most countries of Europe during the decade 1951-60. The principal causes for this decline are rapid urbanization, industrialization, the mechanization of agriculture, improvement of public health services, and especially the mass immunization of children with the DPT or DT vaccines.

Nevertheless, despite the progress that has been made in anti-tetanus vaccination during the decade 1951-60, approximately 26 220 persons died from this disease in 22 countries of Europe with a population of 340 123 000 in the decade 1951-60. To this number could be added 1290 deaths in Bulgaria, where Denchev (1962) gives a mortality rate for tetanus of 1.5 per 100 000 population and 2267 deaths in Romania, where Băcilă et al. (1961) have reported a rate of 1.3. The inclusion of these latter figures brings the total numbers of deaths from tetanus in Europe during the 10-year period to 29 779 in a covered population of 365 108 000, for a mean mortality rate of 0.81. If this rate is correct for the entire population (411 000 000) of Europe (excluding the USSR), it would mean that, in the 10-year period under consideration, 33 000 Euro-

TABLE 11  
DECENNIAL MORTALITY RATES FROM TETANUS PER 100 000 INHABITANTS  
IN SOME COUNTRIES OF EUROPE (1921-60)<sup>a</sup>

Country	1921-30	1931-40	1941-50	1951-60
Austria	—	2.69	1.97	1.02
Denmark	2.49	1.30	1.14	0.34
Finland	—	0.36	0.43	0.11
France	—	—	2.25	1.11
Germany	—	0.64	0.56	0.32
Greece	2.41	2.44	0.47	1.16
Ireland	0.80	0.64	0.55	0.32
Italy	1.88	1.52	2.00	1.17
Malta	9.29	7.03	5.67	1.19
Netherlands	0.60	0.44	0.53	0.20
Norway	0.46	0.33	0.33	0.08
Spain	2.06	1.82	1.63	1.22
Sweden	0.48	0.28	0.24	0.11
Switzerland	0.73	0.30	1.03	0.52
United Kingdom				
England and Wales	0.38	0.26	0.18	0.09
Northern Ireland	0.71	—	0.31	0.24
Scotland	0.31	0.26	0.24	0.11

<sup>a</sup> Data from *Ann. epidem. vital Stat.*, 1951-60.

peans died from tetanus. However, if we were to include the USSR, where, according to Matveev (1960), about 960 to 1000 persons yearly die of tetanus (mortality rate of 0.5), the total number of deaths from tetanus in Europe during the decade 1951-60 must have been more than 40 000, or almost twice as many as during the period 1945-53 (Matveev & Sergeeva, 1959).

In many European countries, tetanus is the cause of more deaths than diphtheria, typhoid fever, scarlet fever and rabies combined (Möse, 1955; Matveev, 1960; Băcilă et al., 1961; Schuch & Windorfer, 1963).

In 1960, the morbidity rate for tetanus per 100 000 population remained high in the following countries; Yugoslavia, 8.20; Hungary, 5.30; Romania, 5.10; Portugal, 4.66; and Bulgaria, 4.10 (Cayolla da Motta, 1957; Băcilă et al., 1961; Denchev, 1962). The southern part of Europe (aside from Portugal, where the mortality rate from tetanus exceeds 3.5 per 100 000 population) must therefore be includ-

ed in the zone of tetanus with mortality rates between 1.0 and 2.0 (Matveev, 1960). A second zone, with a tetanus mortality rate of less than 1.0, covers the areas above 50° north latitude; consequently, one finds a distinct increase in tetanus as one moves from north to south.

The distribution of tetanus cases in any given country is not uniform. In general, most cases occur in rural areas with fertile soil and extensive agriculture. In Yugoslavia, for example, Kacharevic (1952) has noted that a rural population (82%) is more prone to tetanus infection than is an urban population (18%). Usually, in any country, a disproportionately large number of all reported cases of tetanus will be found within a few circumscribed areas. Such foci of infection have been outlined, for example, by Cimmino (1951) in Italy, by Kacharevic (1952) in Yugoslavia, by Möse (1955) in Austria, by Eckmann & Bisaz (1956) in Switzerland, by Weller (1956) in Germany, by Cayolla da Motta (1957) in Portugal, by Zavazal (1957) in

Czechoslovakia, by Matveev (1960) in the USSR, as shown in Fig. 4, by Băcilă et al. (1961) in Romania, by Neyman & Wejdan (1958), Kukiz & Mikulski (1960), Lutynski (1961) and Sawicki (1964) in Poland, by Kubinyi, Rudnai & Barsy (1962-63) in Hungary, as shown in Fig. 5, by Denchev (1962) in Bulgaria, and by Melnotte, Senault & Manciaux (1961) and by Gerbaut et al. (1963) in France. In England and Wales, the highest rates of tetanus morbidity and mortality were observed in the eastern and southern regions (Conybeare & Logan, 1951; Fulford, 1960).

Throughout Europe, with the exception of France, children aged from 2 to 15 years and adults aged from 26 to 30 years, especially in rural areas, suffered from tetanus more frequently than did other portions of the population. In Portugal, for example, 70% of those who died from tetanus during 1955 and 1956 were aged less than 19 years, and 66% were below 14 years of age (Cayolla da Motta, 1957). The predominance of persons in the age-group 2-15 years in the over-all number of tetanus patients also has been reported from Yugoslavia (Kacharevic, 1952), Germany (Hübner & Freudenberg, 1954), Italy (Caruso, 1960; Zonchello, 1961), Bulgaria (Denchev, 1962), Hungary (Petrilla, 1960; Kubinyi, Rudnai & Barsy, 1962-63), from Romania (Băcilă et al., 1961), the USSR (Matveev, 1960; Rossichin, 1962; Nesterenko, 1962), and England and Wales (Cox, Knowelden & Sharrard, 1963). Also, Fulford (1960), in England and Wales, indicated that the number of deaths from tetanus there was highest in boys between the ages of 5 and 15 years. On the other hand, Torres-Gost & Figueroa-Egea (1963a) have indicated that, in Spain, the highest incidence of tetanus was reported in persons aged from 26 to 30 years.

An interesting point that should be stressed here is that most authors who have studied the epidemiology of tetanus in Europe (for example, Matveev, 1960; Denchev, 1962; Torres-Gost & Figueroa-Egea, 1963a) have noticed that the ratio of tetanus in males and females was 2:1, save for the age-group 20-49 years. This ratio has been observed clearly in tetanus neonatorum as well (Kacharevic, 1952).

Because of active immunization programmes, the sex and age distribution of tetanus has shown a marked decrease in children and adult males and a relative increase for women and the elderly in some countries of Europe. This tendency has been noticed in France (Jeune, Vincent & Numbert, 1962; Rapin

& Amstutz, 1963; Gerbaut et al., 1963; Chassagne & Gaigneux, 1964), where the active immunization of soldiers and children against tetanus was initiated about 1936-40 (Ramon, 1962), as well as in some areas of Italy (Chignoli 1961), Germany (Schuch & Windorfer, 1963); Hungary (Kubinyi, Rudnai & Barsy, 1962-63) and the USSR (Nesterenko, 1962).

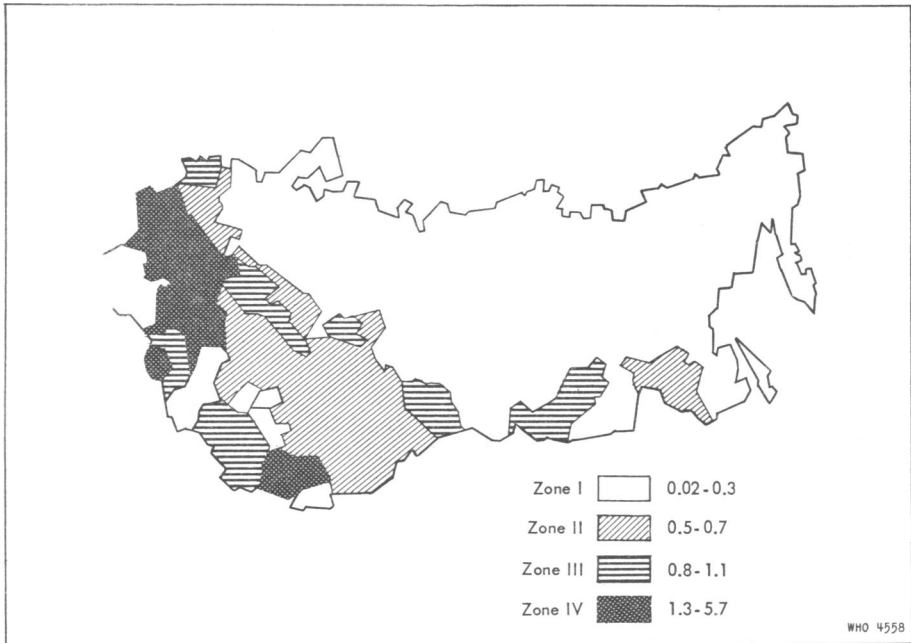
It can be seen from Table 12 that, during the decade 1951-60, the tetanus case fatality in Europe was almost as high as in Asia, which indicates that the latest modes of treatment of this disease, including the use of drugs such as the muscle relaxants and of artificial respiration, either were not very successful or were not available to most tetanus patients.

Supposedly negligible untreated injuries were the main causes of tetanus in Europe. For example, among 2712 cases of this disease reported by Denchev (1962) from Bulgaria, 1763 (65%) were attributable to "trivial injuries". Matveev (1960) reported that, in the Ukraine, about 78% of all cases of tetanus followed such trauma. Approximately the same picture has been drawn by many other investigators, among them Kacharevic (1952), Hübner & Freudenberg (1954), Mincsev (1957), Jeune, Vincent & Numbert (1962), Freudenberg (1963), Rapin & Amstutz (1963), and Cox, Knowelden & Sharrard (1963). A tetanus infection that developed after bee stings has been described by Hübner & Freudenberg (1954), and one that occurred after a finger prick with a sewing needle by Hay (1953).

As a rule, tetanus neonatorum was observed after delivery at home in rural areas. A number of such cases were reported from Yugoslavia (Kacharevic, 1952; Simović, 1958, 1960), from Portugal (Ramalhão, 1956), from Italy (Caruso, 1960; Figueiredo, 1961; Bolletti & Pujatti, 1963), from France (Bayer et al., 1953; Dordain, Jeanne & Evreux, 1963; Gerbaut et al., 1963), from Germany (Hübner & Freudenberg, 1954; Mörl, 1956; Weller, 1956), from Czechoslovakia (Zavazal, 1957; Masar, 1960), from Bulgaria (Denchev, 1962), from Romania (Corneleac & Filimon, 1960; Băcilă et al., 1961), from Hungary (Kubinyi, Rudnai & Barsy, 1962-63), and from Poland (Kukiz & Mikulski, 1960; Sawicki, 1964).

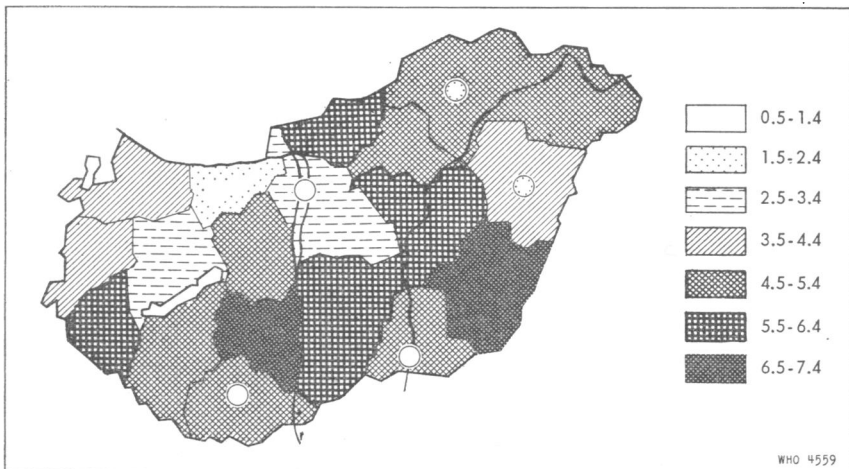
Table 13 shows the case-fatality experience reported by several investigators in Europe. Comparison of this table with Table 1 shows that case fatality from tetanus neonatorum is apparently higher in Europe than in Africa, and comparison with Table 8 indicates that the case-fatality rates

FIG. 4  
GEOGRAPHICAL DISTRIBUTION OF TETANUS IN THE USSR<sup>a</sup>



<sup>a</sup> Morbidity rates per 100 000 population (Matveev, 1960).

FIG. 5  
GEOGRAPHICAL DISTRIBUTION OF TETANUS IN HUNGARY<sup>a</sup>



<sup>a</sup> Incidence per 100 000 population (Kubinyi, Rudnai & Barsy, 1962-63).

TABLE 12  
CASE FATALITY FROM TETANUS IN SEVERAL COUNTRIES OF EUROPE,  
AS REPORTED BY VARIOUS INVESTIGATORS

Country	Author	No. of tetanus cases observed	No. of deaths	Case fatality (%) <sup>a</sup>
Austria	Kaiser (1954)	233	88	37.7
	Möse (1955)	135	51	37.8
Belgium	Lafontaine & Koopmansch (1954)	135	92	68.1
Bulgaria	Denchev (1962)	3 250	1 290	39.7
Czechoslovakia	Masar (1960)	976	412	42.2
Denmark	Perdrup (1949)	527	197	37.4
	Uldall (1961)	63	31	(49.2)
Finland	Savolainen (1951)	13	10	(76.9)
France	Bayer et al. (1953)	279	202	72.4
	Hollender & Schvingt (1955)	21	13	(62.0)
	Jeune, Vincent & Numbert (1962)	172	118	68.6
	Dordain, Jeanne & Evreux (1963)	88	60	68.2
	Gerbaut et al. (1963)	558	246	44.1
	Melnotte & Foliquet (1963)	885	644	76.7
Germany	Rapin & Amstutz (1963)	448	154	34.4
	Hoppe (1952)	85	41	(48.2)
Germany	Mohlenbruch (1952)	197	114	57.8
	Linneweh (1953)	85	51	60.0
	Hübner & Freudenberg (1954)	1 894	930	49.1
	Weller (1956)	507	208	41.0
	Gerster & Moeschlin (1961)	7	2	(28.6)
	Böttger (1962)	100	34	34.0
	Schuch & Windorfer (1963)	23	2	(8.7)
	Greece	Katsilabros (1963)	100	18
Hungary	Kubinyi, Rudnai & Barsy (1962-63)	4 010	1 735	43.2
Italy	Bozzi (1932)	320	164	51.2
	Fiandaca (1946)	70	39	55.7
	Recchia (1956)	631	300	47.5
	Caruso (1960)	349	114	32.6
	Petrone (1960)	2 131	1 486	69.7
	Zauli Naldi & Gasparroni (1961)	28	10	(33.7)
Zonchello (1961)		120	50	41.6
	Poland	Neyman & Wejdan (1958)	317	146
Poland	Lewandowski (1960)	13	4	(30.7)
	Lissner (1960)	35	15	(42.8)
	Kaniak, Cywicki & Smolenska (1960)	230	79	34.3
	Kukiz & Mikulski (1960)	627	288	45.9
Portugal	Ramalhão (1956)	160	48	30.0
Romania	Băcilă et al. (1961)	376	96	25.5
Spain	Torres-Gost & Figueroa-Egea (1963a)	372	216	58.0
Sweden	Nilsson & Nordstrøm (1962)	32	5	(15.6)
	Eriksson & Ullberg-Olsson (1963)	162	62	38.3
Switzerland	Eckmann & Bisaz (1956)	534	231	43.2
	Stirnemann (1963)	149	82	55.0
United Kingdom	Fulford (1960)	2 000	540	27.0
USSR	Matveev (1960)	2 500	930	37.4
	Nesterenko (1962)	540	181	33.5

<sup>a</sup> The figures shown in parentheses are percentages of numbers less than 100.

TABLE 13  
CASE FATALITY IN TETANUS NEONATORUM IN EUROPE,  
AS REPORTED BY VARIOUS INVESTIGATORS

Author	No. of cases observed	No. of deaths	Case fatality (%) <sup>a</sup>
Casorzo & Figueroa (1951)	14	6	(42.8)
Bayer et al. (1953)	5	5	(100.0)
Ramalhão (1956)	6	5	(83.3)
Weller (1956)	52	39	(75.0)
Simović (1958)	14	6	(42.8)
Caruso (1960)	11	8	(72.7)
Corneleac & Filimon (1960)	27	16	(59.2)
Masar (1960)	141	112	79.4
Uldall (1961)	8	6	(75.0)
Figueiredo (1961)	21	15	(71.4)
Zauli Naldi & Gasparroni (1961)	7	5	(71.4)
Denchev (1962)	510	430	81.1
Dordain, Jeanne & Evreux (1963)	5	5	(100.0)
Gerbaut et al. (1963)	24	21	(87.5)
Kubinyi, Rudnai & Barsy (1962-63)	311	229	73.6
<b>Total</b>	<b>1156</b>	<b>908</b>	<b>78.5</b>

<sup>a</sup> The figures in parentheses are percentages of numbers smaller than 100.

for tetanus neonatorum in Europe (78.5%) and Asia (78.9%) appear to be nearly identical.

Among other injuries that are followed by tetanus in Europe, especial note should be made of trauma to the uterus, chronic ulcerations, injections, burns and frostbite (Savolainen, 1951; Bourns, 1953; Henrion, 1954; Hübner & Freudenberg, 1954; Gabele, 1954; Triebold, 1956; Ramsay, France & Dampsey, 1956; Nissen & Enderlin, 1957; Riis, 1958; Garland, 1959; Boyd, Mackay-Scollay & Conybeare, 1959; Matveev, 1960; Deparis, Manigand & Bataillard, 1960; Petrilla, 1960; Woodward, 1960; Jørgensen & Lou, 1961; Denchev, 1962; Jeune, Vincent & Numbert, 1962; and Dordain, Jeanne & Evreux, 1963).

The morbidity of tetanus in the northern and central parts of Europe is closely related to summer work in the fields, being highest in June, July and August (Matveev, 1960; Masar, 1960; Kukiz &

Mikulski, 1960; Denchev, 1962; Kubinyi, Rudnai & Barsy, 1962-63; Torres-Gost & Figueroa-Egea, 1963b). The seasonal distribution of this disease is less pronounced in the southern parts of Europe, where a considerable number of cases of tetanus is sometimes registered during the first and second quarters of the year (Cayolla da Motta, 1957). Notification of this disease, as well as the immunization of children and some other population groups under greatest risk has been made compulsory in Bulgaria, Czechoslovakia, France, Hungary, Poland, Romania, and the USSR. More recently, Portugal<sup>1</sup> and Italy<sup>2</sup> have been added to this list.

To summarize the tetanus situation in Europe, it should be said that the incidence of this disease in that continent during the decade 1951-60 was decreasing slowly because of the active immunization of the population but that many persons, especially adults, remained without protection against this infection.

#### AUSTRALIA AND OCEANIA

On the basis of occasional reports, it may be assumed that tetanus is common in Australia and Oceania (Lancaster, 1953; Hunter, 1959; Alhady et al., 1960; Alhady, 1961; Kennedy, 1960; Clifton, 1961; Forbes, 1961; Maddocks & Dawborn, 1961; Ryan, 1961).

Before 1950, only Australia and New Zealand regularly reported tetanus; the following decennial mortality rates per 100 000 population were reported to WHO:

Years	Australia	New Zealand
1921-30	1.51	0.87
1931-40	1.10	0.50
1941-50	0.89	0.55
1951-60	0.53	0.45

During the decade 1951-60, however, the data received show that the mortality rate from tetanus per 100 000 population was high on Niue Island (26.6), the Cook Islands (23.1), and in French Polynesia (8.8). In 1960, tetanus was listed among the principal causes of death in the Fiji Islands and on Niue Island (World Health Organization, 1963). Altogether, it appears that there were 960 deaths from this cause in Australia and Oceania during the decade in question. However, if the mean mortality

<sup>1</sup> Decree No. 44 198 of 20 February 1962 (*Int. Dig. Hlth Legis.*, 1963, 14, 468).

<sup>2</sup> Law No. 292 of 5 March 1963 (*Int. Dig. Hlth Legis.*, 1963, 14, 654).



rate of 0.7 were correct for the entire population of Oceania during that period, the actual number of deaths would exceed 1000. Indeed, since registration in this area is far from complete, even this latter figure must be considered underestimated.

According to Lancaster (1953), tetanus has caused twice as many deaths as diphtheria in some parts of Australia. During the period 1944-56, Johnson (1956) encountered 195 cases of tetanus in Queensland, and he showed that children between 2 and 15 years of age predominated (88 cases, or 46.3%). Of these 190 cases of tetanus, 89 terminated fatally, thus indicating that the over-all case-fatality rate for tetanus in that area was about 46.8%.

Tetanus neonatorum is important in New Guinea and the adjacent islands (Jones, 1946; Johnson, 1956; Earle & Mellon, 1958). According to Schofield, Tucker & Westbrook (1961), direct observations among the Abelam people of the Sepik District of New Guinea revealed that the incidence of tetanus neonatorum was approximately 80 per 1000 live-births. Immunization of children by means of the DPT vaccine is carried out routinely in Australia, New Zealand, French Polynesia, Papua, and several other places. In order to combat tetanus neonatorum in New Guinea, the immunization of pregnant women has been proposed and initiated quite recently (Schofield, Tucker & Westbrook, 1961).

#### DISCUSSION

Although the tetanus problem is not a new one—indeed, its history is long—it cannot be denied that, to the present time, very little has been learned about the epidemiology of this disease in the world as a whole. For example, only recently was it realized that tetanus is as prevalent in peacetime as it is during wars. Even in the more advanced countries of Europe and North America, detailed studies on the geographical distribution of tetanus were begun no more than 10 to 20 years ago, and many parts of Africa, Asia, and South America remain unexplored in this respect. This neglect of tetanus has occurred largely because there are many other urgent problems with respect to other communicable diseases, such as plague, smallpox, cholera, enteric infections and tuberculosis, which are either responsible for high general morbidity and mortality rates or represent considerable hazards with respect to the possibility of serious outbreaks or epidemics. On the basis of the available statistics and on the

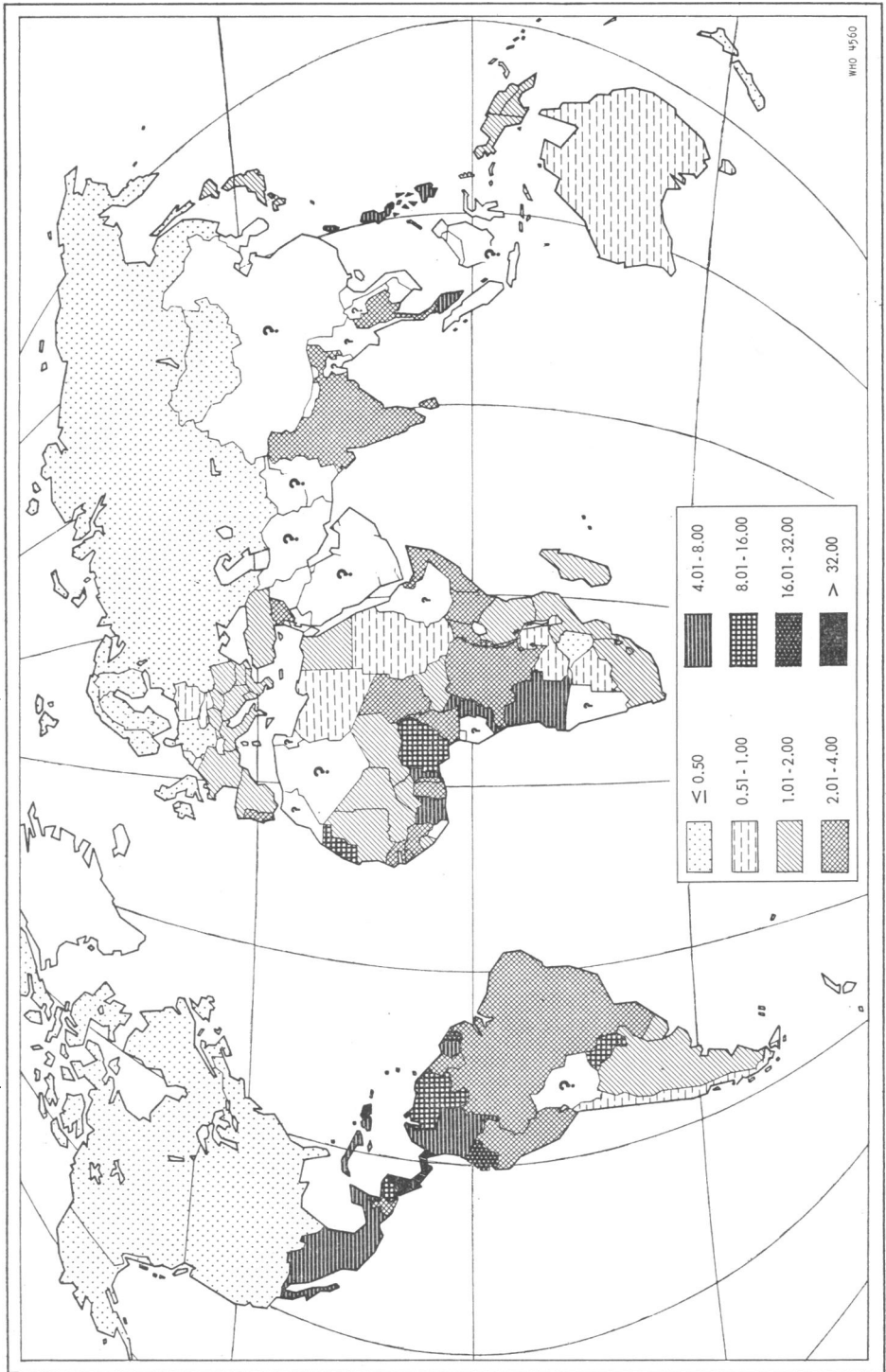
literature, the world-wide distribution of tetanus has been calculated and is presented in Fig. 6.

Since tetanus is so closely related to such an inexhaustible "source" as the soil itself, it is an endemic infection that causes more deaths in the world than rabies, smallpox, plague, anthrax, leptospirosis, poliomyelitis, or many other infectious or parasitic diseases. The present report has demonstrated that tetanus exists in most countries throughout the world, but with considerable differences in morbidity and mortality rates according to various geographical and socio-economic conditions. The existence of various regions that may be described as tetanus "zones" or "foci" proves that the natural distribution of *Clostridium tetani* is not uniform and depends, to a great extent, on certain conditions. The studies conducted in the USA by Dubovsky & Meyer (1922), in France by Lavergne, Helluy & Faivre (1949), in the USSR by Illutovic & Tarasov (1957) and by Matveev (1960), in Poland by Lutynski (1961), and in Bulgaria by Denchev (1962) have indicated that a hot, damp climate, together with a fertile soil rich in organic matter are favourite environments for this organism. Mishustin & Perzovskaya (1954) observed the ability of *Cl. tetani* to persist and multiply in black soil and that the presence of the rhizospheres of wheat stimulates this process. Similar phenomena have been observed by Matveev (1960) in experiments on the behaviour of *Cl. tetani* in dry and wet sand and soil.

There is little doubt that *Cl. tetani*, like many other clostridia, inhabits the soil. However, the nutritional requirements of this organism, as well as its toxigenicity and its ecological relationships with the thousands of other bacteria, fungi, protozoa, algae and plants under natural conditions are practically unknown. As a rule, however, there is a relationship between the frequency of isolations of *Cl. tetani* from the soil of certain areas and the level of morbidity from tetanus (Matveev, Solov'ev & Volkova, 1957; Denchev, 1962; Orzuev & Matveev, 1964).

Consequently, areas in which the incidence of tetanus is very high may be considered to be foci of the disease. Such natural foci of other clostridial diseases have been described elsewhere by Prévot (1955), by Smith (1955), by Matveev (1959, 1960), and by Dolman & Murakami (1961), but the "dynamics" of tetanus foci (that is, the changes that occur in the distribution of *Cl. tetani* in the soil and in the number of cases of tetanus in the same area) have not yet been properly investigated.

FIG. 6  
WORLD INCIDENCE OF TETANUS DURING THE PERIOD 1951-60<sup>a</sup>



<sup>a</sup>Average annual mortality rates per 100,000 population (WHO Annual Epidemiological and Vital Statistics, 1950-64).

In both cultivated and uncultivated areas, an important role in the dissemination of certain toxigenic strains of *Cl. tetani* may be ascribable to certain domesticated animals, such as cattle, horses, sheep and goats. It is very probable, also, that the cultivation of certain plants may influence the *Cl. tetani* population of the soil.

A feature of tetanus foci is their stability, which is obvious from the consistency of the reports on the yearly number of tetanus cases in the same places (Veronesi, 1960; Mattos, 1962; Patel & Mehta, 1963) unless and until there is interference from the public health services.

Social and economic factors such as poverty, ignorance, religious prejudices, unhygienic customs and habits, together with the lack of health services in regions with warm climate and fertile soil, are largely responsible for the high incidence of this disease in some places.

Urbanization, industrialization, and the mechanization of agriculture can interfere with the normal process of distribution of *Cl. tetani* and reduce the morbidity rate, as has occurred, for example, in the USA, the United Kingdom, Germany, and the Netherlands during the last 40 years, even before active immunization against this disease was initiated.

A possible explanation for this phenomenon is that, on the one hand, people in towns and cities have less contact with the soil than do rural populations; on the other hand, the population of *Cl. tetani* in the soil of industrial towns may decline gradually because of the lack of fertilizers. This last speculation has been challenged, however, by the findings of Orzuev & Matveev (1964), who have shown that, in the soil of Tashkent, the capital of the Uzbek SSR, *Cl. tetani* is to be found more often than in the soils of nearby farms. Similarly, the large numbers of tetanus patients that are recorded from some towns in India indicate the possibility that there may be heavy contamination of the soil in those towns with *Cl. tetani*.

Also, the relatively low incidence of tetanus in towns could well be due to the intensive use of antibiotics and other antibacterial agents by urban populations, which may result, indirectly, in the protection of the populace against tetanus (Tateno, Suzuki & Kitamoto, 1961). It is reasonable to suppose, of course, that there may be different reasons in different places for changes in the behaviour of tetanus, and that each such difference should be studied, but the fact does remain that the incidence of tetanus is much lower in urban than in

rural areas (Kacharevic, 1952; Matveev, 1960; Pinheiro, 1960; Barua, 1961; Vaishnava et al., 1964). The highest rates of morbidity from tetanus continue to exist in the developing countries that are situated near the equator. The number of tetanus victims in the world during the decade 1951-60 quite probably exceeded 1 000 000 persons, of whom approximately half died. These figures are several times greater than those calculated by Matveev & Sergeeva (1959), but they should nevertheless be regarded as underestimates of the actual situation.

During the decade under investigation, tetanus proved to be fatal to approximately one half of the patients who contracted it, despite the recent introduction of new modes of treatment. It is noteworthy that case-fatality rates differed between different areas. In Japan, the Philippines and the USA, case fatality was high (60%-78%), in comparison with only 40%-50% in Africa, Asia and Europe. Apart from factors such as differences in public health services, hospital facilities, the period of incubation, the severity of the individual case, methods of treatment, and case distribution by age, sex, profession or season, there may be significant differences in the area distribution of strains of *Cl. tetani* with differing abilities to multiply and to produce toxins in the human body. Also, as has been shown by Illutovic (1961, 1962), strains of this organism that have been isolated from the soils of different areas differed from each other, not only in their toxigenicity, but even in the antigenic structures of the toxins that were produced. Unfortunately, studies of this kind are quite limited in number (Fildes, 1927; Lavergne, Helluy & Faivre, 1949; Orzuev & Matveev, 1964).

During the decade in question, children between the ages of 2 and 15 years, and adults aged between 26 and 30 years, all over the world (except in France) suffered from this disease more than did the members of other age-groups. In some areas, tetanus neonatorum accounted for from 10% to 30% of all cases of tetanus; nevertheless, tetanus is an infection to which persons of all ages are subject, since a large proportion of the persons who suffered from it were adults (Yodh & Shah, 1956; Veronesi, 1960; Patel & Mehta, 1963; Matveev, 1960).

An interesting fact that has been noted by many investigators but that still requires investigation and explanation, is the relatively high incidence of this disease in males, especially newborns, in many countries of Europe and Asia. Kacharevic (1952) was the first author to suggest that males may be

more sensitive to the tetanus toxin than are females, and his experiments with pigs and other animals appear to offer some proof of this thesis. The same idea was put forward independently by Denchev (1962).

The frequent occurrence of tetanus after otherwise trivial injuries, chronic ulcerations, and various kinds of operations, injections and vaccinations has been reported from various countries, indicating that there is a necessity for increased attention to preventive measures against tetanus in all persons who are subject to this type of risk. Because of the strong connexion between tetanus and the soil, there is, at present, no possibility of controlling this infection other than the active immunization of the population at risk. The efficacy of active immunization was proved during the Second World War, during which the American and British armies, whose members had been vaccinated against tetanus, suffered almost no casualties from this disease, in sharp contrast to the experience of the German army, the members of which had not received this protection (Boyd, 1946; Long & Sartwell, 1947).

Because of active immunization, success in combating tetanus has been scored in some countries of Europe, North America, Asia, Australia and Oceania. For the prevention of tetanus after injuries, projects for active-passive prophylaxis against the disease have been reviewed and developed further by Matveev (1960), Eckmann (1960), Filler & Ellerbeck (1960), Laurent & Parish (1960), Tasman & Huygen (1962), Smith et al. (1963), Jannes (1964) and Kremlev (1964).

Experience indicates that the active immunization of pregnant women may help to eradicate tetanus neonatorum (Katitch, 1960; Vuksanović, Kolbas & Sučić, 1960; Băcilă et al., 1961; Schofield, Tucker & Westbrook, 1961; Kubinyi, Rudnai & Barsy, 1962-63; Kril, Prasilava & Neubertova, 1964; Newell et al., 1964).

Nevertheless, during the decade 1951-60, only a small proportion of the world's population was protected against tetanus, despite the fact that tetanus toxoid, which can provide excellent prophylaxis against this disease, was discovered nearly 40 years ago (Ramon & Zoeller, 1926; Ramon, 1962, 1963).

#### SUMMARY

Tetanus, since it is an almost ubiquitous infection, constitutes an important problem in most developing countries. In a major portion of the world, this disease is still not notifiable. Nevertheless, on the basis of available information, it would appear to

be possible to construct a tentative outline of the geographical distribution of tetanus in the world.

As one moves from the polar areas toward the equator, one can see clearly the changes in the morbidity and mortality rates from tetanus, which reach their highest levels in the tropical countries. The distinct seasonal distribution of this infection in countries with cold or moderate climates is found to be less distinct in areas with subtropical or tropical climates. Even within a given country, if it contains a variety of landscapes and climatic conditions, the population that inhabits the areas with warm, damp climates and fertile soil are, as a rule, more prone to tetanus than people who inhabit mountains or deserts, provided that there are no appreciable differences in socio-economic and cultural conditions between these areas.

Factors such as industrialization, urbanization, mechanization of agriculture, the widespread use of chemical fertilizers rather than animal dung, and improvements in education, the standard of living, and public health services, reduced the incidence of tetanus in many European countries, Canada, the USA, Japan and Australia even before the inception of programmes of mass immunization against tetanus. However, the most effective means of combating tetanus within a short period has proved to be the active immunization of the entire population.

In non-immunized populations, children below the age of 15 years suffer from tetanus more often than do persons of greater age. In populations in which immunization programmes have been initiated, one can observe the relative increase in the incidence of tetanus among non-immunized persons as against the gradual over-all decline of the disease. As it has been general practice to protect children and soldiers against tetanus, the disease has become both "younger" and "older", continuing to affect unprotected newborns, women, and the elderly.

In many areas, a difference in incidence between the sexes has been observed, with the predominance of males among the newborn, the age-group 2 to 15 years, and in persons over 50 years of age. These findings suggest that males are more sensitive to tetanus toxin than are females in these age ranges.

The overwhelming majority of cases of tetanus in the world were due to the infection of otherwise negligible injuries to the extremities, particularly the legs. The higher proportions of tetanus neonatorum, post-abortive and post-partum tetanus as well as tetanus after injections, vaccinations, chronic ulcerations, otitis, parasitic and infectious diseases

of the skin, and so on, were common in areas where there is poverty, religious prejudice and unhygienic customs, and where education and public health services are absent or deficient.

The over-all case fatality from tetanus varied widely from place to place, being as high as 60% to

78% in Japan, the Philippines, and the USA and about 40% to 50% in Africa, India, and some European countries, indicating that, during the decade 1951-60, more than 500 000 persons may have died from this disease, which can be easily prevented by vaccination.

## RÉSUMÉ

Le tétanos, infection presque universellement répandue, revêt une grande importance dans la plupart des pays en développement. Bien que dans la plus grande partie du monde la déclaration de cette maladie ne soit pas obligatoire, les informations dont on dispose permettent cependant de dresser à grands traits une carte provisoire de sa répartition géographique.

A mesure que l'on s'avance des régions polaires vers l'équateur, on constate de nettes variations des taux de morbidité et de mortalité par infection tétanique. Ces taux atteignent leur niveau le plus élevé dans les zones tropicales. L'influence des saisons sur la répartition de la maladie, évidente dans les pays à climat froid ou tempéré, s'estompe en revanche dans les contrées à climat tropical ou subtropical. A l'intérieur d'un même pays offrant une certaine variété du sol et des conditions climatiques, les populations des endroits où le climat est chaud et humide et le sol fertile sont habituellement plus exposées au tétanos que les habitants vivant en régions montagneuses ou désertiques.

Dès avant la mise en œuvre des programmes de vaccination antitétanique de masse, certains facteurs ont contribué à réduire l'incidence de la maladie dans beaucoup de pays européens, au Canada, aux Etats-Unis d'Amérique, au Japon et en Australie. Ce sont notamment l'industrialisation et l'urbanisation, la mécanisation de l'agriculture, l'utilisation de produits chimiques au lieu d'engrais d'origine animale, l'élévation du niveau de l'enseignement et du standard de vie, ainsi que l'amélioration des services de santé publique. A court terme, l'immunisation active de l'ensemble de la population reste cependant l'arme la plus efficace.

Dans une population non immunisée, les enfants de moins de 15 ans sont plus fréquemment victimes du tétanos que les personnes plus âgées. Lorsque des vacci-

nations ont eu lieu, on assiste à une augmentation relative des cas de tétanos chez les personnes non immunisées, contrastant avec le déclin progressif et généralisé de l'infection. La vaccination antitétanique, qui s'adresse généralement aux enfants et aux soldats, modifie les données épidémiologiques de l'affection qui frappera surtout les groupes d'âge extrêmes, nouveau-nés non immunisés, femmes, personnes âgées.

On a observé en maints endroits que l'incidence du tétanos n'était pas la même dans les deux sexes. Le sexe masculin, dans les catégories des nouveau-nés, des enfants de 2 à 15 ans et des personnes de plus de 50 ans, est plus fréquemment victime de la maladie. Il semble donc que dans ces groupes d'âge, le sexe masculin soit davantage sensible à la toxine tétanique.

Dans la très grande majorité des cas, le tétanos résulte de l'infection de blessures, par ailleurs anodines, des extrémités, et surtout des jambes. Le tétanos du nouveau-né, le tétanos post-partum ou post-abortum, ainsi que le tétanos résultant d'injections, de vaccinations, d'ulcérations chroniques, d'otites, d'affections cutanées parasitaires ou infectieuses, s'observent principalement dans des régions pauvres, où règnent des préjugés religieux et des habitudes antihygiéniques, aggravés par l'absence ou les lacunes des services d'enseignement et de santé publique.

Le nombre des décès dus au tétanos est très variable suivant les endroits : au Japon, aux Philippines et aux Etats-Unis d'Amérique, la mort survient dans 60-78% des cas, cependant qu'en Afrique, en Inde et dans certains pays européens, la proportion des décès n'est que de 40-50%. On peut estimer à plus de 500 000 le nombre des personnes qui, au cours de la décennie 1951-1960, ont succombé à cette affection qu'il est aisé de prévenir par la vaccination.

## REFERENCES

- Adams, J. Q. & Morton, R. J. (1955) *Amer. J. Obstet. Gynec.*, **69**, 169-173
- Aguileiro, M. J. M., Brahiero, R. L. & Ghigliazza, H. M. (1960) *Sem. méd. Méx.*, **117**, 969-976
- Alhady, S. M. A. (1961) *med. J. Aust.*, **2**, 219-220
- Alhady, S. M. A., Bowler, D. P., Reid, H. A. & Scott, L. T. (1960) *Brit. med. J.*, **1**, 540-545
- Amezquita Urias, G. (1964) *Higiene*, **16**, 123
- Armengaud, M. (1959) *Bull. et Mem. Fac. mixte Méd. Pharm. Dakar*, **7**, 296

- Armengaud, M., Frament, V. & Biram, D. (1960) *Méd. Afr. noire*, **7**, 264
- Armengaud, M., Louvain, M. & Diop-Mar, I. (1962) *Bull. et Mem. Fac. mixte Méd. Pharm. Dakar*, **10**, 172-179
- Armengaud, M., Louvain, M., Diop-Mar, T. & Sanokho, A. (1963) *Bull. Soc. Méd. Afr. noire Langue franç.*, **8**, 75-101
- Arora, V. D., Desai, A. V. & Kazi, S. (1963) *Tetanus in children in a general hospital*. In: Study Group of Tetanus, *International conference on tetanus*, Bombay, Birla Matushri Sabhaghar, p. 39
- Ashhurst, A. P. C. (1926) *J. Amer. med. Ass.*, **87**, 2089
- Athavale, V. B. (1963) *Clinical manifestations of tetanus neonatorum*. In: Study Group of Tetanus, *International conference on tetanus*, Bombay, Birla Matushri Sabhaghar, p. 39
- Axnick, M. W. & Alexander, E. R. (1957) *Amer. J. publ. Hlth*, **47**, 1493
- Ayyar, R. D., Ramakrishnan, S. P. & Birenda Singh (1963) *Antiseptic*, **60**, 371-379
- Băcilă, E., Ciocirile, C., Javorovsci, V., Teodorescu, G. & Margineanu, T. (1961) *Microbiologia (Buc.)*, **6**, 425-430
- Back, E. H. (1960) *Lancet*, **2**, 601
- Bahia, A. (1953) *Matern. e Inf. (S. Paulo)*, **12**, 189-200
- Baker, W. (1963) *E. Afr. med. J.*, **40**, 127-131
- Baker, W. & Grounds, J. G. (1964) *E. Afr. med. J.*, **41**, 93-96
- Barua, A. R. (1961) *J. Indian med. Ass.*, **37**, 270-274
- Barua, A. R. (1963) *Study of 383 consecutive cases of tetanus*. In: Study Group of Tetanus, *International conference on tetanus*, Bombay, Birla Matushri Sabhaghar, p. 38
- Basu, K. S. (1963) *Indian med. J.*, **57**, 124-125
- Bayer, J., Corre-Hurst, L., Sapin-Jaleustre, H. & Tissier, M. (1953) *Presse méd.*, **61**, 701-703
- Beheyte, P. (1950) *Ann. Soc. belge Méd. trop*, **30**, 341-348
- Beisser, O. (1960) *Berita Departemen Kesehatan Republic Indonesia*, **2**, 5-12
- Bernard, J. G., Gallay, C. & Laverdant, C. (1963) *Rev. Immunol. (Paris)*, **27**, 145-161
- Bhatt, A. N. & Anwikar, A. K. (1962) *J. Indian med. Ass.*, **38**, 71-75
- Binechvar & Ghavampour, M. (1954) *Rev. Fac. Méd. (Téhéran)*, **11**, 681-686
- Bolletti, M. & Pujatti, G. (1963) *Acta paediat. lat. (Reggio Emilia)*, **14**, 225-256
- Böttger, G. (1962) *Münch. med. Wschr.*, **104**, 853
- Botticelli, J. T. & Waisbren, B. A. (1961) *Amer. J. med. Sci.*, **242**, 44-50
- Bourns, N. K. (1953) *Brit. med. J.*, **1**, 491
- Boyce, F. F. & McFetridge, E. M. (1935) *New Orleans med. surg. J.*, **87**, 825
- Boyd, J. S. (1946) *Lancet*, **1**, 113-119
- Boyd, J., Mackay-Scollay, E. M. & Conybeare, E. T. (1959) *Proc. roy. Soc. Med.*, **52**, 109-114
- Bozzi, E. (1932) *Osped. maggiore Novara*, **20**, 213
- Bryant, J. & Fairman, N. E. (1940), *Lancet*, **2**, 263
- Bunch, G. H. & Quattlebaum, J. (1943) *Amer. J. Surg.*, **61**, 180-185
- Calvin, J. K. (1930) *Amer. J. Dis. Child.*, **39**, 674-675
- Calvin, J. K. & Goldberg, A. H. (1930) *J. Amer. Med. Ass.*, **94**, 1977-1981
- Cantrelle, P. A., Etifier, J. & Masse, N. (1960) *Mortalité et morbidité de l'enfance en Afrique*. In: Université de Dakar et Centre international de l'Enfance, *Journées africaines de Pédiatrie (Dakar, 16-17 avril)*, pp. 66-79
- Caruso, G. (1960) *Acta med. ital. Mal. infett.*, **15**, 249-254
- Carvalho, A. A. & Nascimento, C. A. (1950) *Arch. Hig. (S. Paulo)*, **28**, 199-209
- Casorzo, L. & Figueroa, L. (1951) *Arch. Soc. Ciruj. Chile*, **3**, 73-93
- Cayolla da Motta, L. (1957) *Bol. Serv. Saúde públ. (Lisboa)*, **4**, 477-501
- Chassagne, P. & Gaigneux, Y. (1964) *Bull. Inst. nat. Hyg.*, **19**, 489-510
- Chignoli, V. (1961) *Acta med. ital. Mal. infett.*, **16**, 280
- Cimmino, A. (1951) *Nuovi Ann. Ig.*, **2**, 241-257
- Clifton, B. S. (1961) *Med. J. Aust.*, **1**, 618-624
- Conybeare, E. & Logan, W. (1951) *Brit. med. J.*, **1**, 504-508
- Corneleac, V. & Filimon, E. (1960) *Microbiologia (Buc.)*, **5**, 273-276
- Cox, C. A., Knowelden, J. & Sharrard, W. J. W. (1963) *Brit. med. J.*, **2**, 1360-1366
- Creech, O. Jr, Glover, A. & Ochsner, A. (1957) *Ann. Surg.*, **146**, 369
- Critchley, A. (1958) *Publ. Hlth (Lond.)*, **71**, 459-469
- Denchev, V. (1962) [*Trans. Res. Inst. Epidem. Microbiol. (Sofia)*], **8**, 73-82
- Deparis, M., Manigand, C. & Bataillard, J. (1960) *Rev. Prat. (Paris)*, **10**, 463-465
- De Reus, T. (1963) *Ned. T. Geneesk.*, **107**, 1265-1267
- Dolman, C. E. & Murakami, L. (1961) *J. infect. Dis.*, **109**, 107-128
- Dordain, M., Jeanne, C. & Evreux, R. (1963) *Rev. Hyg. Méd. soc.*, **11**, 69-79
- Dubovsky, J. & Meyer, K. (1922) *J. infect. Dis.*, **31**, 614-616
- Earle, A. M. & Mellon, W. L. (1958) *Amer. J. trop. Med. Hyg.*, **7**, 315-316
- Eckmann, L. (1960) *Tetanus: Prophylaxe und Therapie*, Schwabe, Basel & Stuttgart
- Eckmann, L. & Bisaz, E. (1956) *Schweiz. med. Wschr.*, **86**, 641-645
- Eriksson, E. & Ullberg-Olsson, K. (1963) *Comparison between modern intensive therapy and ordinary treatment of tetanus. A review of the Swedish tetanus cases 1950-1960*. In: Study Group of Tetanus, *International conference on tetanus*, Bombay, Birla Matushri Sabhaghar, p. 65
- Fiandaca, R. (1946) *Riv. Policl. inf.*, **6**, 326
- Figueiredo, I. (1961) *Rev. méd. Aero. (Rio de J.)*, **13**, 40-53
- Figueroa, P. E. R. & Romero, H. R. (1963) *Rev. venez. Sanid.*, **28**, 104-112

- Fildes, P. (1927) *Brit. J. exp. Path.*, **8**, 219-226
- Filler, R. M. & Ellerbeck, W. (1960) *J. Amer. med. Ass.*, **174**, 1-4
- Floch, H. (1949) *Bull. Acad. nat. Méd. (Paris)*, **133**, 419-422
- Fonseca, D., Irastorza, J. F., Ferreira, R. M., Ferreira, E. & Roncaglio, A. (1961) *An. Fac. Med. Montevideo*, **46**, 108-123
- Forbes, J. A. (1961) *Med. J. Aust.*, **2**, 72-73
- Forde, H. M. & Williams, H. M. (1960) *W. Indian med. J.*, **9**, 9-13
- Fournier, A. & Cabanel, G. (1957) *Algérie Méd.*, **5**, 577
- Francisco, R. (1944) *Clinics*, **3**, 373-414
- Freudenberg, E. (1963) *Schweiz. med. Wschr.*, **93**, 1319-1326
- Fulford, G. E. (1960) *Lancet*, **1**, 1121-1123
- Gabele, A. (1954) *Zbl. Gynäk.*, **76**, 1604-1617
- Gandy, J. (1950) *Bull. Inst. Hyg. Maroc*, **10**, 319-322
- Garland, H. (1959) *Proc. roy. Soc. Med.*, **52**, 877-880
- Garza Brito, A. (1955) *Bol. Epidem. (Méx.)*, **19**, 36-38
- Gerbaut, P., Lorrain, J., Weber, M. & Canton, P. (1963) *Ann. Méd. Nancy*, **2**, 1086-1096
- Gerster, P. & Moeschlin, S. (1961) *Dtsch. med. Wschr.*, **86**, 890-897, 927-928
- Gessner, H. B. & Adiger, D. (1916) *New Orleans med. surg. J.*, **69**, 91
- Ghosh, S. M. (1950) *J. Indian med. Ass.*, **19**, 328
- Ghosh, S. & Soni, S. (1961) *Indian J. Child Hlth*, **10**, 440-449
- Gomez, J. J. O., Barrios, I. C., Guerrero, L. M., Guevara, A. G. & Parra, M. G. (1960) *Higiene*, **12**, 199-208
- Gordon, J. E., Singh, S. & Wyon, J. B. (1961) *J. Indian med. Ass.*, **37**, 157-161
- Graves, A. M. (1930) *Ann. Surg.*, **92**, 1075
- Greenfield, I. (1963) *Etiology, pathogenesis and clinical features of tetanus*. In: Study Group of Tetanus, *International conference on tetanus*, Bombay, Birla Matushri Sabhaghar, p. 36
- Grounds, J. G. (1964) *J. trop. Med. Hyg.*, **67**, 257-259
- Gwee, A. L. & Lee, Y. K. (1962) *Singapore med. J.*, **3**, 174-177
- Gwee, A. L. & Nadarajah, I. (1960) *Singapore med. J.*, **1**, 164-166
- Hanna, W. A. (1958) *Brit. med. J.*, **1**, 460-461
- Harper, J. (1961) *Med. J. Malaya*, **16**, 32-45
- Hay, K. M. (1953) *Brit. med. J.*, **1**, 733
- Hazra, A. K. & Agnihotri, S. R. (1960) *Indian J. med. Sci.*, **14**, 197-200
- Heath, C. W., Zusman, J. & Sherman, T. L. (1964) *Amer. J. publ. Hlth*, **54**, 769-779
- Henrion, C. (1954) *Brux.-méd.*, **34**, 232, 238
- Heredia, A. F. (1963) *Prevention of surgical tetanus in the tropics*. In: Study Group of Tetanus, *International conference on tetanus*, Bombay, Birla Matushri Sabhaghar, p. 66
- Hines, E. A. (1930) *Amer. J. Dis. Child.*, **39**, 560-572
- Hollender, L. & Schvingt, E. (1955) *Acta chir. belg.*, **3**, 251-266
- Hoppe, J. (1952) *Chirurg.*, **23**, 353
- Hübner, A., & Freudenberg, K. (1954) *Rev. Immunol. (Paris)*, **18**, 344
- Hunter, W. J. (1959) *Med. J. Aust.*, **2**, 98-99
- Huntington, R. W., Thompson, W. R. & Gordon, N. H. (1937) *Ann. Surg.*, **105**, 93
- Ikram-Ul-Haq (1964) *Medicus (Karachi)*, **29**, 97-108
- Illutovic, A. U. (1961) *Ž. Mikrobiol. (Mosk.)*, No. 3, pp. 76-80
- Illutovic, A. U. (1962) *Ž. Mikrobiol. (Mosk.)*, No. 11, pp. 123-126
- Illutovic, A. U. & Tarasov, J. D. (1957) *Sborn. naučnic trudov Stavropolsk naučnoissledovatel'skogo Instituta Vakcin i Syvorotok*, **4**, 243-273
- Indian Research Fund Association (1946) *Report of the fourth meeting of the Indian Clinical Research Advisory Committee*, Bombay, India
- Indonesia, Ministry of Health, Division of Statistics (1957) *Causes of deaths in hospitals, 1957*, Djakarta
- Indonesia, Ministry of Health, Division of Statistics (1958) *Causes of deaths in hospitals, 1958*, Djakarta
- Int. Dig. Hlth Legis.*, 1963, **14**, 468, 654
- Jain, R. C. (1962) *J. Indian med. Ass.*, **38**, 405-409
- Jannes, L. (1964) *Brit. J. exp. Path.*, **14**, 498-501
- Jelliffe, D. B. (1950) *Arch. Dis. Childh.*, **25**, 190
- Jelliffe, D. B. (1958) *Diseases of children in the sub-tropics and tropics*. Arnold, London, pp. 1-28
- Jeune, M. M., Vincent, P. & Numbert, G. (1962) *Rev. lyon. Méd.*, **11**, 1331-1338
- Joag, J. G. (1963) *Incidence of tetanus in the Sholapur district during 1961 and 1962*. In: Study Group of Tetanus, *International conference on tetanus*, Bombay, Birla Matushri Sabhaghar, p. 62
- Johnson, D. W. (1956) *Med. J. Aust.*, **2**, 710-715
- Johnstone, D. D. (1958) *Brit. med. J.*, **1**, 12-16
- Jones, R. (1946) *N.Z. med. J.*, **45**, 423
- Jørgensen, K. R. & Lou, H. (1961) *Ugeskr. Læg.*, **123/8**, 264-268
- Kacharevic, D. Z. (1952) *Glas. Khig. Inst.*, **2-4**, 1-21
- Kaiser, M. (1954) *Wien. klin. Wschr.*, **66**, 727-730
- Kaniak, R. V., Cywicki, J. & Smolenska, W. (1960) *Przegl. epidem.*, **14**, 177-181
- Katitch, R. V. (1960) *Rev. Immunol.*, **24**, 521-524
- Katsilabros, L. (1963) *High doses of adrenaline in the treatment of tetanus*. In: Study Group of Tetanus, *International conference on tetanus*, Bombay, Birla Matushri Sabhaghar, p. 59
- Keet, M. P. & Murray, A. B. (1962) *S. Afr. med. J.*, **37**, 401-404
- K.E.M. Hospital Group (1963a) *Analysis of various aspects in 4839 patients with tetanus*. In: Study Group of Tetanus, *International conference on tetanus*, Bombay, Birla Matushri Sabhaghar, p. 35
- K.E.M. Hospital Group (1963b) *Presence of Cl. tetani on various parts of the body*. In: Study Group of Tetanus, *International conference on tetanus*, Bombay, Birla Matushri Sabhaghar, p. 43
- Kennedy, D. P. (1960) *N.Z. med. J.*, **59**, 551

- Kirtley, J. A. Jr. (1940) *Amer. J. Surg.*, **49**, 480-484
- Klenerman, P. & Scragg, J. (1955) *S. Afr. med. J.*, **29**, 853-854
- Kloetzel, K. (1963) *J. Amer. med. Ass.*, **185**, 559-567
- Kloetzel, K. & Monteiro, D. M. (1963) *Rev. Inst. Med. trop. S. Paulo*, **5**, 111-117
- Kochhar, K. S. (1960) *Indian J. Surg.*, **21**, 29-34
- Kremlev, G. I. (1964) *Ž. Mikrobiol. (Mosk.)*, No. 12, pp. 39-43
- Kril, R., Prasilava, F. & Neubertova, E. (1964) *Clin. Pediat. (Pologna)*, **46**, 509-517
- Kubinyi, L., Rudnai, O. & Barsy, G. (1962-63) *Acta microbiol. Acad. Sci. hung.*, **9**, 133-143
- Kukiz, T. & Mikulski, Z. (1960) *Przegl. epidem.*, **14**, 117-126
- Lacaz, C. S., Mattos, A. G., Galvão, A. L. A. & Souto, A. B. (1955) *J. Pediat. (Rio de J.)*, **20**, 120
- Lafontaine, A. & Koopmansch, W. (1954) *Brux.-méd.*, **34**, 411-414
- Laha, P. J. & Vaishya, P. D. (1963) *A study of the incidence of 1000 cases of tetanus in Gwalior and its neighbouring districts*. In: Study Group of Tetanus, *International conference on tetanus*, Bombay, Birla Matushri Sabhaghar, p. 63
- Lambotte-Legrand, J. & Lambotte-Legrand, C. (1950) *Ann. Soc. belge Méd. trop.*, **30**, 541-546
- Lancaster, H. (1953) *Med. J. Aust.*, **2**, 417-418
- La Scala, F. (1958) *J. Pediat. (Rio de J.)*, **23**, 383-392
- Laurent, L. J. M. & Parish, N. J. (1960). *Lancet*, **2**, 494
- Lavergne, V., Helluy & Faivre, G. (1949) *Rev. Immunol. (Paris)*, **13**, 315-324
- Leal, G. (1945) *Arch. venez. Pueric.*, **7**, 1353
- Lebon, J., Choussat, N. & Chaussat-Clausse, J. (1949) *Bull. Acad. nat. Méd. (Paris)*, **133**, 42-45
- Lepine, P. (1960). In: *Proceedings of the Symposium on Immunization in Childhood*. Edinburgh & London, Livingstone, p. 89
- Lessard, R., Potvin, A. & Morin, Y. (1960) *Canad. med. Ass. J.*, **83**, 1199-1202
- Levandowski, A. (1960) *Przegl. epidem.*, **14**, 163-169
- Lewis, R. A., Satoskar, R. S., Joag, G. G., Dave, B. T. & Patel, J. C. (1954) *J. Amer. med. Ass.*, **39**, 630-634
- Limaye, M. R. (1962) *J. Indian med. Ass.*, **39**, 630-634
- Linneweh, F. (1953) *Med. Klin.*, **48**, 195
- Lissner, M. (1960) *Przegl. epidem.*, **14**, 171-173
- Loh Siew Gek (1951) *Med. J. Malaya*, **5**, 181-194
- Long, A. P. & Sartwell, P. E. (1947) *Bull. U.S. Army med. Dep.*, **7**, 371-385
- Lue, Hung-Chi (1960) *Mem. Col. Med. Taiwan Univ.*, **6**, 57-69
- Lutynski, R. (1961) *Przegl. epidem.*, **15**, 285-288
- Maddocks, J. & Dawborn, J. K. (1961) *Med. J. Aust.*, **1**, 625-626
- Mahadevan, B. (1963) *Incidence and prevention of tetanus, with particular reference to the armed forces*. In: Study Group of Tetanus, *International conference on tetanus*, Bombay, Birla Matushri Sabhaghar, p. 71
- Malpica, M. (1961) *Higiene*, **13**, 61-62
- Masar, J. (1960) *Čs. Epidem.*, **9**, 156-162
- Mathur, H. H. & Singh, R. V. (1963) *Tetanus, a clinical study*. In: Study Group of Tetanus, *International conference on tetanus*, Bombay, Birla Matushri Sabhaghar, p. 37
- Mattos, A. G. (1962) *Pediat. práct. (S. Paulo)*, **33**, 269-276
- Matveev, K. J. (1959) [*Botulism*], Moscow, Medgiz, pp. 147-153
- Matveev, K. J. (1960) [*Epidemiology and prophylaxis of tetanus*], Moscow, Medgiz, vol. 3, pp. 12-25, 59-60
- Matveev, K. J. & Sergeeva, T. U. (1959) *Ž. Mikrobiol. (Mosk.)*, **2**, 134-142
- Matveev, K. J., Solov'ev, S. V. & Volkova, Z. M. (1957) *Ž. Mikrobiol. (Mosk.)*, **3**, 54-58
- Matveyev, M. P. & Paul, S. S. (1959) *Indian J. Child Hlth*, **8**, 181-194
- Melnotte, P. & Foliguet, J. M. (1963) *Rev. Hyg. Méd. soc.*, **11**, 51-64
- Melnotte, P., Senault, R. & Manciaux, M. (1961) *Concours méd.*, **83**, 2733-2742
- Menon, K. A. (1960) *Med. J. Malaya*, **14**, 184-186
- Mincsev, M. (1957) *Zbl. Chir.*, **82**, 1-26, 17-27
- Miranda, G. G. & Hempel, Y. B. (1962) *Rev. méd. C. Rica*, **29**, 297-304
- Mishustin, E. N. & Perzovskaya, M. J. (1954) [*Microorganisms and the self-purification of the soil*], Moscow, Publishing House of the Academy of Sciences of the USSR
- Modi, N. J. (1963) *Some observations on 554 cases of tetanus*. In: Study Group of Tetanus, *International conference on tetanus*, Bombay, Birla Matushri Sabhaghar, p. 38
- Mohlenbruch, A. (1952) *Chirurg*, **8**, 357
- Montgomery, R. D. (1961) *W. Indian med. J.*, **10**, 84-101
- Moore, R. M. & Singleton, A. O. (1939) *Surg. Gynec. Obstet.*, **69**, 146
- Mörl, F. (1956) *Z. artz. Fortbild.*, **50**, 535-538
- Möse, J. R. (1955) *Arch. Hyg. (Berl.)*, **139B**, 137-147
- Moynihan, N. H. (1956) *Brit. med. J.*, **1**, 260-264
- Murray, K. D. (1959) *Med. J. Aust.*, **2**, 659
- Murti, B. R., Bhaskaran, C. S. & Rajyalakshmi, K. (1961) *J. Indian med. ass.*, **37**, 187-189
- Musoke, L. K. (1961) *Arch. Dis. Childh.*, **36**, 305-315
- Natkunam, R. (1960) *Ceylon med. J.*, **5**, No. 3, 123-124
- Nazareth, F. A. & Edibam, B. C. (1959) *Indian J. Child Hlth*, **8**, 349-356
- Nenes, D. P. & Tranchesi, J. (1948) *Rev. Hosp. Clin. Fac. Med. S. Paulo*, **3**, 99-106
- Nesterenko, L. P. (1962) *J. Microbiol. Epidem. Immunobiol.*, **12**, 65-70
- Newell, K. W., Lehmann, A. D., LeBlanc, D. R. & Osorio, N. G. (1964) *Bull. Wld Hlth Org.*, **30**, 439-444
- Neyman, K. & Wejdan, H. (1958) *Przegl. epidem.*, **12**, 135-145
- Nilsson, E. & Nordström, L. (1962) *Nord. Med.*, **67**, 122-124
- Nissen, R. & Enderlin, F. (1957) *Dtsch. med. Wschr.*, **82**, 539-543



- Noel, O. F. (1950) *Sth. med. J. (Bgham, Ala.)*, **43**, 53-56
- Oliveira, N. (1958) *J. Pediat. (Rio de J.)*, **23**, 80-96
- Onuigbo, W. J. B. (1963) *J. trop. Pediat.*, **9**, 85-87
- Oropeza, P. (1937) *El tetanos infantil en Venezuela*, Caracas, Tipografia Americana (Thesis)
- Orzuev, M. I. & Matveev, K. I. (1964) *Ž. Mikrobiol. (Mosk.)*, No. 12, pp. 11, 94-99
- Pai, D. N. (1963) *Tetanus mortality in India*. In: Study Group of Tetanus, *International conference on tetanus*, Bombay, Birla Matushri Sabhaghar, p. 63
- Parikh, V. V. (1963) *The incidence of tetanus : a survey in Kheralu Taluka*. In: Study Group of Tetanus, *International conference on tetanus*, Bombay, Birla Matushri Sabhaghar, p. 62
- Patel, J. C. (1960) *J. Obstet. Gynaec. India*, **11/12**, 188-192
- Patel, J. C., Dhirawani, M. K. & Trivedi, R. R. (1960) *Indian J. Child Hlth* **9**, 459-468
- Patel, J. C. & Mehta, B. C. (1963) *Indian J. med. Sci.*, **17**, 791-811
- Patel, J. C., Mehta, B. C. & Nanavati, B. H. (1963) *J. Indian med. Ass.*, **40**, 443-447
- Perdrup, A. (1949) *Acta chir. scand.*, **97**, 495-502
- Perin, F. & Van de Voorde, R. R. (1963) *Ann. Soc. belge Méd. trop.*, **43**, 225-240
- Perlstein, M. A., Stein, M. D. & Elam, H. (1960) *J. Amer. med. Ass.*, **173**, 1536-1541
- Petrilla, A. (1960) *Acta microbiol. Acad. Sci. hung.*, **7**, 65-70
- Petrone, P. (1960) *Ann. Sclavo*, **2**, 684-691
- Pinheiro, D. (1957) *J. Pediat. (Rio de J.)*, **51**, 171-180
- Pinheiro, D. (1960) *J. bras. Med.*, **3**, 729-746
- Pinheiro, D. (1962) *Pediat. prat. (S. Paulo)*, **33**, 263-268
- Pirame, Y. (1963) *Presse méd.*, **71**, 1045-1046
- Pirame, Y. & Becquet, R. (1963) *Bull. Soc. Path. exot.*, **56**, 469-474
- Poesponegoro, S. D. & Ranti, J. S. F. (1959) *J. Indones. med. Ass.*, **9**, 1-11
- Portsmouth, O. H. D. (1963) *E. Afr. med. J.* **40**, 643-648
- Prévot, A. R. (1955) *Biologie des maladies dues aux anaerobies*, Paris, Flammarion
- Ramalhão, J. (1956) *Portugal méd.*, **40**, 96-111
- Ramon, G. (1962) *Rev. Immunol. (Paris)*, **26**, 185-284
- Ramon, G. (1963) *Rev. Hyg. Méd. soc.*, **11**, 47-49
- Ramon, G. & Zoeller, M. (1926) *C.R. Soc. Biol. (Paris)*, **94**, 106
- Ramsay, A. M., France, E. M. & Dampsey, B. M. (1956) *Lancet*, **2**, 548-550
- Rapin, M. & Amstutz, P. (1963) *Rev. Hyg. Méd. soc.*, **11**, 47-49
- Recchia, F. (1956) *Mal. Infez.*, **2**, 355-416
- Riis, P. (1958) *Nord. Med.*, **60**, 1048-1049
- Rojas, M., Weitman, J., Moya, H., Segovia, M., Jimenez, L., Villalobos, M., Tello, A. & Rodo, F. (1960) *Rev. méd. Chile*, **88**, 349-358
- Rossichin, V. V. (1962) *J. Microbiol. Epidemiol. Immunobiol.*, **4**, 120-121
- Ryan, B. (1961) *Papua N. Guinea med. J.*, **5**, 27-29
- Salvaraglio, F. & Ebole, O. (1950) *Ann. Inst. Hyg. Montevideo*, **4**, 59-71
- Sarrouy, C., Gillot, F., Clause, J., Peretti, E. & Gatto, L. (1956) *Algérie méd.*, **60**, 277-290
- Sarrouy, C., Gillot, F. & Pantin (1950) *Pédiatrie*, **5**, 777-778
- Savolainen, T. (1951) *Acta path. microbiol. scand.*, **91**, 177-180
- Sawicki, F. (1964) *Przegl. epidem.*, **18**, 71-76
- Schlesinger, B. E. (1960) In: *Proceedings of a symposium on immunization in childhood*, London, Livingstone, p. 73
- Schofield, F. D., Tucker, V. M. & Westbrook, G. R. (1961) *Brit. med. J.*, **2**, 785-789
- Schuch, P. & Windorfer, A. (1963) *Dtsch. med. Wschr.*, **88**, 2181-2188
- Sen, R., Vaishnava, H. & Passey, M. N. (1963) *Bacteriological investigations in clinical cases of tetanus in Delhi*. In: Study Group of Tetanus, *International conference on tetanus*, Bombay, Birla Matushri Sabhaghar, p. 44
- Sénécal, J. (1958) *Tetanus*. In: *Diseases of children in the subtropics and tropics*, Jelliffe, D. B., ed., London, Arnold, pp. 594-600
- Sénécal, J. & Senghor, G. (1962) *Turk. J. Pediat.*, **4**, 98-102
- Shah, R. M., Shah, L. J. & Damany, S. I. (1962) *Indian J. med. Sci.*, **16**, 867-872
- Sharma, D. P. (1963) *Study of 510 cases of tetanus admitted in P.L.S. Hospital, Meerut in last 3 years*. In: Study Group of Tetanus, *International conference on tetanus*, Bombay, Birla Matushri Sabhaghar, p. 38
- Sheth, S. (1956) *Indian J. Pediat.*, **23**, 197-199
- Silva, C. C. (1960) *J. Ceylon publ. Hlth Ass.*, **1**, 61-67
- Silva Martinez, M. (1964) *Higiene*, **16**, 110-122
- Silverthorne, N. (1947) *J. Pediat.*, **30**, 195-198
- Simović, N. (1958) *Ann. paediat. (Basel)*, **190**, 237-251
- Simović, N. (1960) *Jugosl. Pediat.*, **3**, 1-4, 53-58
- Sinha, B. N. (1961) *J. Indian med. Ass.*, **36**, 286-288
- Skudder, P. A. & McCarroll, J. R. (1964) *J. Amer. med. Ass.*, **188**, 625-627
- Slome, R. (1954) *S. Afr. med. J.*, **28**, 473-475
- Smith, J. W. G., Evans, D. G., Jones, D. A., Gear, M. W. L., Cunliffe, A. C. & Barr, M. (1963) *Brit. med. J.*, **1**, 237-238
- Smith, L. D. (1955) *Introduction to the pathogenic anaerobes*, Chicago, University of Chicago Press, pp. 48-49, 77-79, 88-107, 126-129
- Smythe, P. M. (1963) *Brit. med. J.*, **1**, 565-571
- Smythe, P. M. & Bull, A. B. (1961) *Brit. med. J.*, **1**, 732-736
- Spaeth, R. (1941) *Arch. intern. Med.*, **68**, 1133-1160
- Spivey, O. S., Grulee, C. G., Hickman, B. T. & Stewart, S. E. (1953) *J. Pediat.*, **42**, 345
- Srivastava, S. P. & Chatterji, G. G. (1961) *J. Indian med. Ass.*, **36**, 289-295
- Stahlie, T. D. (1960) *J. trop. Pediat.*, **6**, 15-18
- Stirnemann, U. (1963) *Schweiz. med. Wschr.*, **16**, 601-607

- Syngal, K. L. (1961) *Indian J. Child Hlth*, **10**, 190-194
- Takos, M. J. (1958) *Industr. Med. Surg.*, **27**, 518-519
- Tasman, A. & Huygen, F. J. A. (1962) *Bull. Wld Hlth Org.*, **26**, 397-407
- Tateno, I., Suzuki, S. & Kitamoto, O. (1961) *Jap. J. exp. Med.*, **31**, 365-380
- Taxay, E. P. (1960) *W. Ind. med. J.*, **9**, 14-16
- Thiodet, J., Fourrier, A., Massonat, J. & Deyme, H. (1956a) *Algérie méd.*, **60**, 41-43
- Thiodet, J., Fourrier, J., Massonat, J. & Deyme, H. (1956b) *Algérie méd.*, **60**, 45-47
- Tompkins, A. B. (1958) *Brit. med. J.*, **1**, 1382-1385
- Tompkins, A. B. (1959) *Arch. Dis. Childh.*, **34**, 398-405
- Top, F. H., Huggen, D. W. & McCulloch, W. F. (1964) *An epidemiological study of tetanus in Iowa*, Iowa City, State University of Iowa
- Torres-Gost, J. & Figueroa-Egea, J. (1963a) *Determinative factors of tetanus*. In: Study Group of Tetanus, *International conference on tetanus*, Bombay, Birla Matushri Sabhaghar, p. 37
- Torres-Gost, J. & Figueroa-Egea, J. (1963b) *Mortality in tetanus*. In: Study Group of Tetanus, *International conference on tetanus*, Bombay, Birla Matushri Sabhaghar, p. 37
- Tran Van Bang & Nguyen Duy San (1960) *Acta med. vietnam.*, **4**, 1239-1241
- Triebold, H. (1956) *Gynaecologia (Basel)*, **142**, 129
- Turner, V. C. & Galloway, T. C. (1949) *Arch. Surg.*, **58**, 478-483
- Uldall, T. (1961) *Ugeskr. Læg.*, **123/26**, 907-911
- Uttley, K. H. (1959) *W. Indian med. J.*, **8**, 41
- Vaishnava, H., Neogy, C. N., Dixit, N. S., Passey, M. N., Gupta, S. C. & Laurence, D. R. (1964) *J. Ass. Phycns India*, **12**, 691-701
- Vakil, B. J., Aiyer, S. N., Tulpule, A., Mehta, A. J. & Tulpule, T. H. (1964) *J. Indian, med. Ass.*, **42**, 203-212
- Vakil, B. J., Tulpule, T. H., Armitage, P. & Laurence, D. R. (1963) *Clin. Pharmacol. Ther.*, **4**, 182-187
- Vener, H. J. & Bower, A. G. (1941) *J. Amer. med. Ass.*, **116**, 1627
- Veronesi, R. (1956) *Amer. J. med. Sci.*, **232**, 629-647
- Veronesi, R. (1960) *Contribuição para o estudo clinico e experimental do tetano*, São Paulo (Thesis)
- Vervoorn, J. D. (1962) *Trop. geogr. Med.*, **14**, 284-286
- Vinnard, R. T. (1945) *Surgery*, **18**, 482-492
- Von Reuss, A. R. (1927) *Diseases of the newborn*, New York, Word & Co.
- Vuksanović, V., Kolbas, V. & Sučić, V. (1960) *Jugosl. Pediat.*, **3**, 98-106
- Wagle, C. S. (1963) *Indian J. med. Sci.*, **17**, 157-159
- Wainwright, J. M. (1926) *Arch. Surg.*, **12**, 1062
- Weller, E. (1956) *Dtsch. med. Wschr.*, **81**, 267-272
- Wilkinson, J. L. (1961) *Brit. med. J.*, **1**, 1721-1724
- Woodward, W. W. (1960) *Brit. med. J.*, **2**, 916
- World Health Organization (1963) *Second report on the world health situation, 1957-1960*, Geneva (*Off. Rec. Wld Hlth Org.*, **122**)
- Wright, R. (1960) *S. Afr. med. J.*, **34**, 111-113
- Wright, R., Symes, M. K., Jackson, B. G., Mann, N. M. & Adams, E. B. (1961) *Lancet*, **1**, 678-680
- Yazdani, I. (1954) *Rev. Fac. Méd. (Teheran)*, **11**, 513-522
- Yeoh, G. S. (1960) *Singapore med. J.*, **1**, 59-62
- Yodh, B. B. & Shah, S. N. (1956) *J. Ass. Phycns India*, **4**, 337-341
- Young-En Kao (1948) *Chin. med. J.*, **66**, 487-493
- Young-En Kao (1951) *Chin. med. J.*, **69**, 512-517
- Zauli Naldi, G. & Gasparroni, L. (1961) *Clin. Pediat. (Bologna)*, **43**, 550-558
- Zavazal, V. (1957) *Z. arztl. Fortbild.*, **57**, 133-136
- Zonchello, S. A. (1961) *Arch. ital. Sci. med. trop.*, **17**, 198-208
- Zubillaga, R. A. (1952) *Arch. venez. Pueric.*, **15**, 180-204