Bull. Org. mond. Santé
Bull. Wld Hlth Org. } 1958, **19**, 747-758

ENDEMIC AND EPIDEMIC TRENDS OF POLIOMYELITIS IN CENTRAL AND SOUTH AMERICA*

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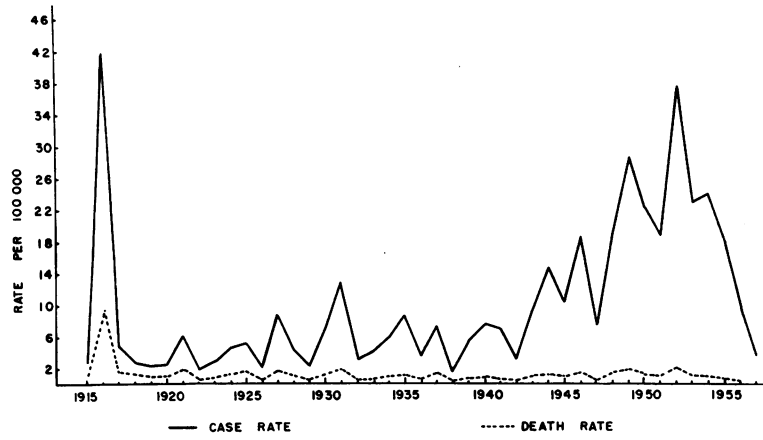
SYNOPSIS

An inverse ratio between infant mortality rates and poliomyelitis case rates has been observed rather constantly in some parts of the world. The available data from Latin America have been examined in this connexion and, there also, the ratio seems to hold moderately well. A general supposition both for Latin America and elsewhere is that in countries where the infant mortality rate falls below 75 per 1000 live births, the poliomyelitis case rate will bear watching, since although the disease may not have been much of a problem in such countries in the past, experience has shown that it may suddenly or gradually become one.

It is now fairly well recognized that during the past half century or more the epidemiological behaviour of poliomyelitis has been undergoing a certain amount of evolution, from a sporadic disease of infants to an epidemic disease of older children and even adults. This transition, which seems to be linked to local " ways of living ", was apparently first noticed in Scandinavia, in the 1880's; it was observed in other parts of Europe at almost the same time, and in North America shortly afterwards, i.e., in the early years of the twentieth century. The first epidemics of poliomyelitis in a given area were often, but by no means always, sudden and large—so-called " primary outbreaks "—and they were usually followed by a gradual rise in the 5-year case rate, which might reach a level of from 5 to 10 times greater than that recorded in pre-epidemic days. What the story has been in the USA is illustrated in Fig. 1. However, evolutional experiences of this kind have not been universal, for in many parts of the world—notably in North and South Africa, Egypt and the Middle East, and in certain countries in Latin America—the transition from sporadic " infantile paralysis " to epidemic poliomyelitis has apparently not yet begun.

* This study was aided by a grant from the National Foundation for Infantile Paralysis, Inc., New York, N.Y., USA.

FIG. 1. POLIOMYELITIS CASE AND DEATH RATES PER 100 000 IN THE USA, 1915-56



Prior to 1915, reporting of poliomyelitis was incomplete, but what case rates are available show them to be at levels of under 2 per 100 000 in most states. Prior to 1920, almost all cases were in infants below the age of 6 years, but by 1950 about 25 % or more were in people 15 years of age or older. The effect of the Salk vaccine began to be noticeable in 1955.

Central and South American countries have experienced this transition somewhat later than has Europe and the USA, for, in 1940, almost all of the American countries south of the USA, including the Caribbean Islands, presented the old-fashioned picture of so-called " infantile paralysis ", comparable to that which characterized this disease almost everywhere at the end of the nineteenth century. Cuba (Paul, Corria & Horstmann, 1949) and Trinidad were exceptions, for epidemic poliomyelitis appeared early there. Nevertheless, the characteristic picture of the disease in Latin America in 1940 consisted of: a low recorded case rate—less than 1 to 2 per 100 000 (or 10 to 20 per million); no records of epidemics of any size; an *infantile* disease with the great majority (80% or more) of the cases occurring in children under 5 years of age, and a dearth of cases in adults who had been born and brought up locally within these areas (Paul, 1957). Since 1940, this situation has remained stationary in some of these countries, whereas in others, poliomyelitis case rates have gradually increased (at least this has been true up to 1955) and in still others, sudden and extensive epidemics have recently been recorded, reminiscent of the 1916 epidemic in the USA (Lavinder, Freeman & Frost, 1918) (see Fig. 1). The last-mentioned situation occurred in Costa Rica in 1954, in Jamaica in 1954 (Grant & Peat, 1957), and in British Guiana in 1957 (Melnick, 1958), and there are several other such examples.

It is likely that neither in Central and South America nor elsewhere have we seen the last of these precipitous epidemics, or the last of the transitions from sporadic, infantile paralysis to the modern scourge of epidemic

poliomyelitis with its gradual tendency to include older and older age-groups among its victims.

The subject of inquiry to be considered here, representing as it does a kind of problem which is by no means limited to Latin America, can best be expressed in terms of two questions:

1. What are the mechanisms which bring about a gradual or sudden transition from sporadic to epidemic poliomyelitis?

2. Could one predict approximately when such a transition might occur?

These questions, particularly the second one, are of more than academic interest because they concern programmes of vaccination against poliomyelitis in certain areas. For instance, in many countries or populations in the world today, where poliomyelitis exists as " infantile paralysis ", with a characteristic low recorded case rate, it would appear that this disease presents no local problem of real medical importance. Consequently, such countries might seem ill advised at the moment to embark on expensive or extensive vaccination campaigns. On the other hand, it could be of considerable importance to know, not only whether the recorded case rate is deceptively low, due to gross under-reporting, but also what the chances might be of paralytic poliomyelitis becoming a more serious local problem in the immediate or near future.

To return to the first question, which seeks an explanation for the transition from endemic " infantile paralysis " to periodically recurring epidemics of this disease, the opinion has been expressed (Paul, 1954; WHO Expert Committee on Poliomyelitis, 1954) that the epidemic behaviour of modern poliomyelitis is associated with modern ways of living—notably, with those public health measures which are effective in raising the level of environmental sanitation within a given area.

Obviously this is a complex subject, for a relationship of morbidity rates for poliomyelitis to sanitary arrangements could be the result of a number of possibilities. First is the simple fact that in certain areas where poliomyelitis appears to be a relatively insignificant problem, and where sanitary arrangements are primitive, mechanisms for the discovery and listing of poliomyelitis cases are apt to be primitive too. Consequently, there is apt to be under-reporting. Another possible explanation for a dearth of recognized cases of poliomyelitis under these same conditions is that any endemic or sporadic disease is less likely to be reported (notified) than is the same disease when it appears in epidemic form. Another reason why the infantile form of the disease might be of low incidence is that, as with a number of other virus infections, infantile infections are apt to be the mildest of the clinical forms. Among infants who become infected with polioviruses, more than 99% fail to develop any symptoms which would attract the attention of physicians, and this great fraction of so-called " inapparent

infections " obviously goes unnoticed, undiagnosed and certainly unreported. But when the disease moves into an older age-group, composed of school-children and young adults, an increasingly larger fraction of the cases comes to the surface. More than 1% of the infected persons in this group develop symptoms, or in other words the age-specific ratios of paralytic to inapparent infections go from 1:99 to 2:98 and continue to increase progressively with advancing age.

This explanation rests on more than theory, for the frequency of inapparent infections with polioviruses in infancy as compared with that later in life can now be measured by surveys of serum antibodies. These serological determinations leave no doubt that both infection and antibody response to polioviruses appear later in life in the juvenile populations of Northern Europe (Paul, Melnick & Riordan, 1952) and North America (Isacson, Melnick & Walton, 1957; Le Bouvier, 1957) than they do in the populations of North Africa (Paul et al., 1952; Paul & Horstmann, 1955, 1956) and of certain Central (Horstmann & Saenz [1]) and South American countries (Melnick, 1958).

As to an explanation of the age distribution of diagnosed cases, it follows that when modern sanitation began to protect infants and young children, an immediate result was a postponement of the age when the infection was acquired. More and more children reached the age of 8, 10 or 12 years without having had the " benefit " of previous exposure and its accompanying natural immunization to polioviruses. When, somewhat inevitably, these carefully nurtured children did become infected, the clinical signs of the infection were more apt to be severe, the level of recognition of the disease rose and this automatically increased the recorded incidence of cases. From the standpoint of epidemics an even more striking effect results—namely, that in so-called well-sanitated areas a sizeable fraction of the juvenile population can grow up as non-immunes, becoming riper each year, so to speak, for an epidemic. This kind of a situation progresses until polioviruses do eventually penetrate into the local community and an epidemic ensues. Such an epidemic can be quite spectacular and the larger the size of the non-immune population, the larger the epidemic. This situation stands in contrast to that of previous days when infants were more or less universally infected and became naturally immunized, early in life, at a price of course. Under such conditions, with much infantile disease, including poliovirus infections, the vulnerable, non-immune fraction of the population was constantly kept small and the chances of an epidemic getting started or amounting to much were correspondingly small.

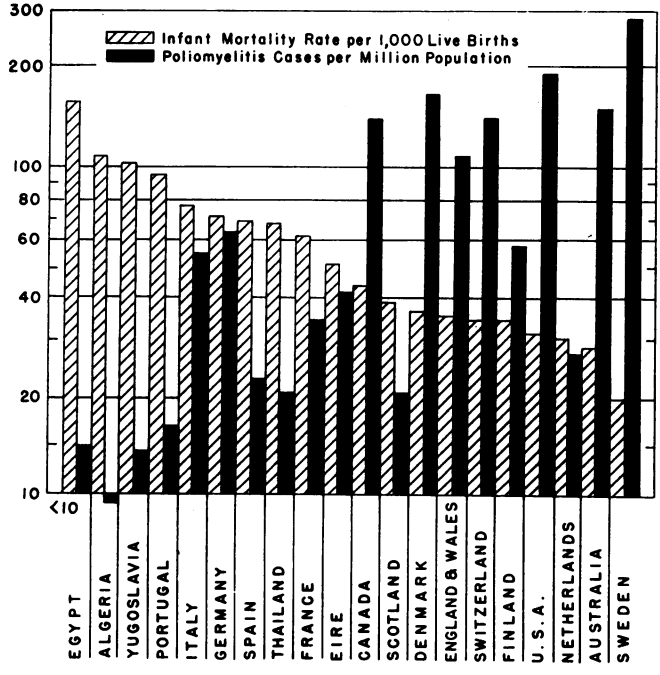
If the above theories are correct, it would be important to have an index for measuring the degree of sanitation which might reflect potentialities for the " epidemic state ". Measurements of this kind are not

[1] Unpublished report of the Yale Poliomyelitis Study Unit, 1958.

easily made, particularly when one considers the extent to which environments can differ as far as sanitation is concerned. Nevertheless, certain indices of sanitation have been devised. One of them can be expressed in terms of infant mortality rates—the definition being the number of children dying in their first year of life per 1000 live births. As a general rule such infant mortality rates reflect the prevalence of those serious infections which are apt to attack infants in a given locality. However, there are a variety of other and indirect ways in which an excess of infant deaths could exert its effect upon local disease patterns (Anderson, 1953). This is reflected in the age composition as well as in the susceptibilities of the " surviving " population.

Payne (1955, 1958) has compared relationships between infant mortality rates and poliomyelitis case rates on a global basis and has pointed out a number of provocative considerations. As a broad generalization his data, some of which are illustrated in Fig. 2, indicate that in those countries where the 5-year-average infant mortality rates are lower than 75, the 5-year-

FIG. 2. INFANT MORTALITY RATES AND POLIOMYELITIS CASE RATES IN VARIOUS COUNTRIES *



It can be seen that, in general, high infant mortality rates are accompanied by low poliomyelitis rates and *vice versa*.

* Based on data presented by Payne (1955)

INFANT MORTALITY RATES (PER 1000 LIVE BIRTHS) AND POLIOMYELITIS CASE RATES (PER 100 000) IN FIVE NORTH, CENTRAL AND SOUTH AMERICAN COUNTRIES

(Based mainly on data supplied by the Pan American Sanitary Bureau)

Year	Infant mortality rate		Poliomyelitis case rate		Infant mortality rate		Poliomyelitis case rate	
	annual	5-year average	annual	5-year average	annual	5-year average	annual	5-year average
	MEXICO				**BRITISH GUIANA**			
1940	125.7		0.1		104.2		2.0	
1941	123.0		0.1		84.4		1.7	
1942	118.2		0.1		96.9		0.0	
1943	117.2		0.1		141.2		0.0	
1944	113.5	119.5	0.2	0.12	135.7	112.5	0.0	0.72
1945	107.9		0.1		101.0		0.0	
1946	110.6		1.1		86.9		0.0	
1947	95.0 *		0.9		86.6		1.0	
1948	101.7		2.7		76.8		0.0	
1949	106.4	104.3	2.8	1.52	75.5	85.3	0.0	0.20
1950	96.2		3.1		85.0		0.5	
1951	98.8		7.0		76.9		1.2	
1952	89.8		2.9		81.8		0.5	
1953	95.2 *		6.4		79.3		0.5	
1954	80.5	92.1	2.1	4.30	76.0	79.8	0.6	0.66
1955			6.1		70.0		1.5 **	
1956			2.0				0.2 **	
1957							13.9 **	
	ARGENTINA				**CANADA**			
1940	90.2		1.9†		56.4		1.7	
1941	84.8		3.5†		60.0		16.4	
1942	86.1		9.1		53.8		5.9	
1943	80.0		10.5		53.7		2.8	
1944	81.2	84.5	3.3	5.6	54.7	55.7	5.8	6.5
1945	82.1		2.5		51.3		3.2	
1946	74.0		4.2		47.6		20.6	
1947	77.7		2.9		46.1		18.3	
1948	69.5		3.4		44.2		9.1	
1949	67.0	74.0	6.6	3.9	43.3	46.5	18.6	13.9
1950	68.2		3.4		41.3		6.7	
1951	67.4		5.8		38.4		18.4	
1952	64.9 *		3.9		38.0		33.0	
1953	65.2 *		14.0		35.4		60.2	
1954	61.9 *	65.5 *	4.6	5.5	31.8	36.9	15.7	26.8
1955			2.3				6.5	
1956			33.1				3.9	
1957								
	USA							
1940	47.0		7.4					
1941	45.3		6.8					
1942	40.4		3.1					
1943	40.4		9.3					
1944	39.8	42.6	14.3	8.2				
1945	38.3		10.3					
1946	33.8		18.3					
1947	32.2		7.5					
1948	32.0		19.0					
1949	31.3	33.5	28.3	16.7				
1950	29.2		22.1					
1951	28.4		18.5					
1952	28.4		37.2					
1953	27.7		22.5					
1954	26.6	28.0	23.9	24.8				
1955			17.7					
1956			9.4					
1957								

* Provisional

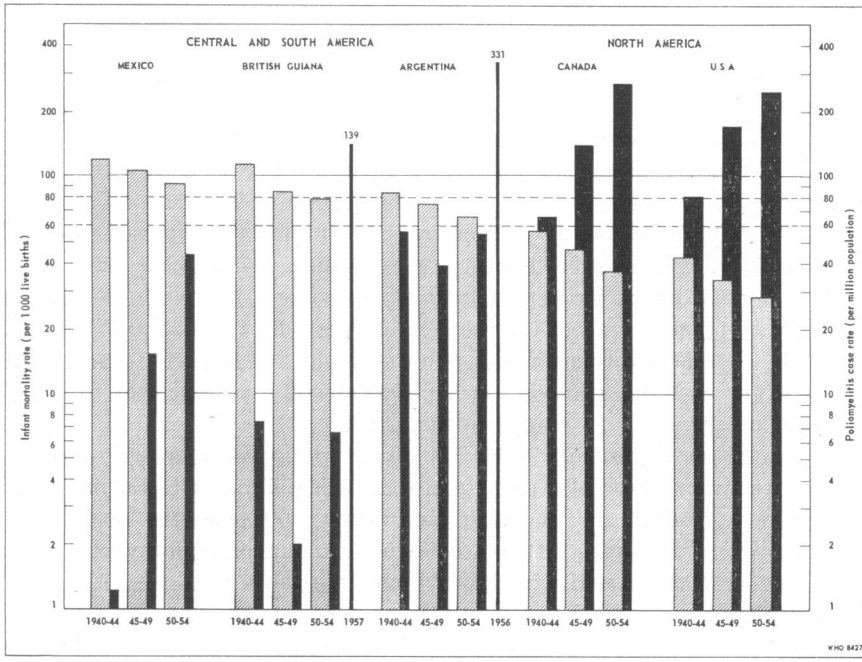
** From Melnick (1958)

† Estimated from data recorded in *Bol. Offic. sanit. panamer.*, 1944, **23**, 586

average poliomyelitis case rates, as a rule, are high, higher than 5 per 100 000 (50 per million).

A similar comparison is attempted in the present study for three 5-year periods (1940-44, 1945-49, and 1950-54) in a number of Central and South American countries.[1] The available morbidity data from Latin America leave much to be desired and do not lend themselves well to a study in which the rates from one country are to be compared with those from another. On the other hand, some of these data, which are presented in the accompanying table, are adequate enough to lend themselves to chronological (or sequential) comparative observations *within the same country*.

FIG. 3. 5-YEAR-AVERAGE INFANT MORTALITY RATES (PER 1000 LIVE BIRTHS) AND POLIOMYELITIS RATES (PER MILLION) IN THREE COUNTRIES IN CENTRAL AND SOUTH AMERICA AND TWO IN NORTH AMERICA, 1940-54



Infant mortality rate (5-year average)

Poliomyelitis case rate (5-year average)

Poliomyelitis case rate for one year

The horizontal zone outlined by the dotted lines indicates what might be called a " critical infant mortality zone ".

[1] Data for these analyses were kindly supplied by the Pan American Sanitary Bureau.

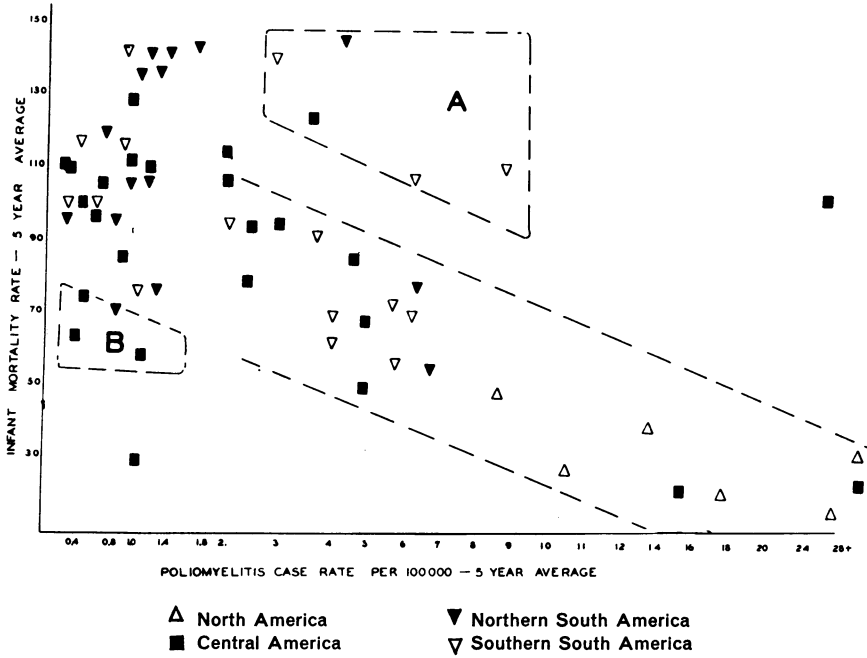
Several examples of such national comparison, covering fifteen consecutive years (1940-54), appear in Fig. 3, which is based on the data presented in the table for three Central and South American countries—Mexico, British Guiana, and Argentina—and for two North American countries—Canada and the USA. The infant mortality rates in each of these countries show a decline during this 15-year period. Within the same period the poliomyelitis case rates have been irregular, but on the whole have risen gradually. Whether there is a causal relationship between these two trends (the downward and the upward) is too complicated a subject to warrant much discussion here. It is certainly worthy of considerable further research. In any event it will be the limited purpose of this report to present some of the available data and then consider the degree to which they could be used in the prognosis of local poliomyelitis situations. In Fig. 3 the three Latin American countries have been selected advisedly to indicate that in two of them a severe epidemic of poliomyelitis, with an annual case rate of more than 130 per million, followed within a few years of the time when the local infant mortality rate had reached what can be designated as the " sensitive zone ", i.e., between 60 and 80 infant deaths per 1000 live births.

This pattern has by no means been completely consistent. How consistent it has been within the Latin American area can perhaps be estimated from Fig. 4. Here, available data collected from the entire western hemisphere since 1940 (with the exclusion of all the island populations, except Trinidad) are charted in the form of a " scatter graph ". Infant mortality rates (5-year average) have been plotted against corresponding poliomyelitis case rates in 22 countries during the period 1940-54. In some of these countries data were not complete for all of the three 5-year periods (1940-44, 1945-49 and 1950-54), so that information based on a single 5-year period had to be used. In the end, this compilation has given us 62 5-year periods for analysis—in other words, 62 points on the graph.

It can be seen from Fig. 4 that the 34 *low* poliomyelitis rates—and for this the arbitrary figure of a rate equal to 20 per million or lower has been chosen—are grouped for the most part (almost 90%) in the upper left-hand corner of the graph. If it holds true that higher poliomyelitis rates are, in general, associated with lower infant mortality rates, i.e., less than 75 infant deaths per 1000 live births, then the great majority of points in the lower half of the graph should fall within a zone which would run obliquely downwards from left to right. To some extent this seems to be the case. About 80% of the 28 points which record 5-year-average poliomyelitis rates greater than 25 per million fall within this oblique zone, and the same holds for the 23 points which record an infant mortality below 75, for 90% of these points also fall in this zone.

There are, however, a number of notable exceptions. Thus, two points —one in the centre right and the other in the bottom left-hand corner— are completely out of line with the others. Five points lie grouped well

FIG. 4. INFANT MORTALITY RATES PLOTTED AGAINST POLIOMYELITIS CASE RATES FOR 22 COUNTRIES IN CENTRAL AND SOUTH AMERICA



Each of the 62 points represents a 5-year average for one of the three periods 1940-44, 1945-49, and 1950-54. The areas marked A and B contain small groups of ratios which lie, respectively, above and below the usual trends.

above the oblique zone, in the area marked A. Four of these points which lie above the usual trend come from two countries, Chile and Costa Rica. No explanation is offered except to say that one might take refuge in the possibility that the rates are inaccurate or point out that, as Chile is a land which has long had a notoriously high infant mortality rate, some special factors may be operative there.

As for the four points which fall below the oblique zone, in the area marked B, these indicate a low infant mortality rate and a low poliomyelitis case rate. Here again one might suggest inaccuracy of reporting, or one might say that these represent situations which may be ripe for an epidemic. Of these four points, three are from Panama—two of them representing data from the Republic of Panama and one representing data from the US-controlled Panama Canal Zone. In the Republic of Panama poliomyelitis rates were low in 1940-44 and 1945-49, in the face of a low infant mortality rate. Apparently this situation did not last for more than one decade, however, for in the subsequent year, 1950, the Panamanian poliomyelitis rate jumped to 11 per 100 000—the first big epidemic in the area—and in

1956 a rate of 15.5 per 100 000 was recorded. The point in area B representing the Panama Canal Zone covers the period 1940-44. Subsequently, in 1947 and 1948, the rate for poliomyelitis in the Zone rose to 36 and 21 per million, respectively, and these figures, when averaged with those for the other three years in that half decade (1945-49), yields a point in the oblique zone. The fourth point in area B represents British Guiana, and covers the 1950-54 period. Soon after this 5-year period, in 1957, British Guiana experienced its first poliomyelitis epidemic (Melnick, 1958) with a case rate of about 14 per 100 000 (see Fig. 3). One could at least say, therefore, that apart from the ever-present possibility of inaccurate data the " situations " in area B of Fig. 4 might have been prophetic, indicating that an epidemic was just around the corner. The dangers of such prognostications are, of course, obvious, and yet, if the results charted in Fig. 4 mean anything, the chances that such a prognostication might be significant could reach 80%.

Mention has been made of the fact that, with the exception of Trinidad, data from island communities were not included in Fig. 4, since it was thought that an inverse ratio between infant mortality rates and poliomyelitis case rates would not hold for such communities—an opinion originally expressed by Payne (1955, 1958). Our data available from 15 islands in the Caribbean Sea are far from complete, but to test Payne's impression, a scatter graph similar to that of Fig. 4 was prepared, and, although the correlation held for some of the islands, there was no such marked trend as that observed in Fig. 4. Presumably this may mean that, granted that a given island population is ripe for an epidemic, the ease with which polioviruses are *introduced* into the community is apt to be less than it would be in the case of a mainland community, presumably because of the isolated or insular character of the population.

ACKNOWLEDGEMENTS

Acknowledgement is made to the Pan American Sanitary Bureau (WHO Regional Office for the Americas), Washington, D.C., for assistance in providing the data which have made this report possible.

RÉSUMÉ

Au cours du dernier demi-siècle, la poliomyélite — appelée « paralysie infantile » — qui était une maladie sporadique affectant surtout les très jeunes enfants s'est transformée en une maladie de caractère épidémique, frappant les enfants plus âgés et même les adultes. Cette évolution, sensible en Scandinavie dans les 20 dernières années du XIX^{e} siècle déjà, s'est manifestée au début du XX^{e} siècle dans d'autres parties de l'Europe et en Amérique du Nord. Il semble qu'en Afrique du Nord, en Afrique du Sud, en Egypte et dans la région de la Méditerranée orientale, cette évolution n'a pas encore commencé. En Amérique du Sud et en Amérique centrale, la maladie présentait encore, vers 1940, ses caractères

anciens: 1-2 cas annuels par 100 000 habitants, 80% ou plus des cas survenant chez des enfants de moins de 5 ans. De 1954 à 1957, la situation s'est modifiée dans certains pays de l'Amérique latine, où de brusques épidémies ont été signalées. Ce processus n'est certainement pas achevé. En suivant ce qui s'est passé en Amérique latine au cours de ces dernières années l'auteur se demande quels sont les facteurs qui déterminent la transformation de la maladie sporadique en maladie épidémique, et si l'on peut prévoir l'apparition de cette transition.

Il a été suggéré que cette évolution était liée à l'élévation du niveau de vie, plus particulièrement à l'assainissement du milieu. Plusieurs facteurs interviennent sans doute dans le rapport entre le taux de morbidité et l'amélioration des conditions de vie: une meilleure déclaration des cas (qui va de pair avec de meilleures conditions de vie); la bénignité de l'infection chez une proportion d'enfants pouvant atteindre 99%, qui n'attire pas l'attention du médecin et échappe à la déclaration.

Lorsque l'amélioration des conditions du milieu commence à protéger les jeunes enfants, l'âge auquel l'infection est contractée est plus avancé. De plus en plus nombreux sont les enfants qui atteignent 8, 10 ou 12 ans sans avoir été en contact avec le virus et sans posséder l'immunité correspondante. Au moment où ces enfants s'infectent, ils développent une forme de la maladie plus grave, aisément reconnue et régulièrement déclarée. Il va sans dire que les enfants non immunisés par une infection bénigne précoce sont la proie facile d'une épidémie. La sérologie confirme ces faits. Les anticorps poliomyélitiques apparaissent plus tard dans la vie des enfants de l'Europe septentrionale et de l'Amérique du Nord que chez ceux de certains pays de l'Amérique centrale ou de l'Amérique du Sud.

Si la relation entre l'évolution de la poliomyélite et l'élévation du niveau de vie se vérifie, peut-on trouver un indice d'assainissement, annonciateur d'un changement virtuel ? L'un des indices proposés est le taux de mortalité infantile — le nombre d'enfants mourant dans leur première année, par 1000 naissances vivantes. Il est connu que ce taux baisse notablement lorsque l'amélioration des conditions de vie diminue les risques d'infections graves des nourrissons. La comparaison des taux de mortalité infantile et des taux de morbidité poliomyélitique suggère que, dans les pays où la mortalité infantile descend au-dessous de 75, la moyenne quinquennale des cas de poliomyélite dépasse 5 pour 100 000. L'auteur indique, pour l'Amérique latine, les chiffres qui, dans l'ensemble confirment cette théorie. La « zone critique de mortalité infantile » correspond à peu près, pour les divers pays, à une mortalité infantile de 60-80. Cette coïncidence n'est cependant pas constante. Elle n'est que rarement observée dans les îles, peut-être parce que le virus a moins de chance de pénétrer dans les collectivités insulaires, isolées, que dans les terres continentales.

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CORRIGENDUM

Vol. 19, No. 1

LA FIÈVRE JAUNE DANS LA FÉDÉRATION D'ÉTHIOPIE ET D'ÉRYTHRÉE

Page 21, paragraph 3 of summary, line 1

delete *Anopheles*
insert *Aëdes*